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ABSTRACT

This collection of student activities for grades four through twelve presents action-oriented experiences with hardy aquatic organisms as the foundation for a laboratory-oriented science program. The format is characterized by pre-lab, post-lab, and student sections. Pre-lab topics include level, concepts, facts, suggested prerequisite skills, student performance objectives, materials, time, cautions, and definition of terms. The teacher's post-lab section includes possible answers to questions, discussion, evaluation, follow-up experiences, and references. Student sections, appropriate for copying, contain general information, objectives, materials, student discovery activities, and processes. (CS)

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Marine Organisms in Science Teaching

John D. Hunt, Editor

Sea Grant College Program
Texas A&M University
TAMU-SG-80-403
September 1980

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John Hunt

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Introduction

Marine Organisms in Science Teaching was developed in 1980 to fulfill a need for a laboratory-oriented science program for grades four through twelve. It presents action-oriented experiences with hardy organisms that can be maintained for periods of time at very little expense and effort in any classroom.

Each activity presented has been classroom tested.

The material consists of "hands-on" student investigations which should be considered sample lessons only. To be of maximum value, the activities should be supplemented and integrated with other lessons, preferably in units. Each individual teacher is the expert and, with this expertise, should be able to adapt these lessons to meet student needs. By using these activities as a guide, teachers will soon become adept in designing others.

Marine Organisms in Science Teaching may be used as a basic science program in conjunction with classroom textbooks and resources. It will help the teacher with little or no marine science background get the students involved in scientific investigations. It is presented in a discovery-type format and includes pre-lab and post-lab sections for the teacher and a student investigation section.

The pre-lab topics include:

- Level
- Concepts
- Facts
- Suggested Prerequisite Skills
- Student Performance Objectives
- Materials, Time, Cautions
- Definition of Terms

In the teachers' post-lab section, the headings are:

- Possible Answers to Questions
- Discussion: Application/implications
- Evaluation
- Follow-up Experiences
- References

The student section contains:

- General information
- Objective
- Materials
- Student Discovery Activities
- Processes

The pre-lab, post-lab and student sections are separated so that the student section can be removed to make ditto or stencil masters. This allows the teacher to provide a classroom set or individual student copies.

Lesson Format

The **Concept(s)** are configurations the student should discover in doing the activities.

The **Facts** are basic information for the teacher. They are examples and are not exhaustive.

The **Suggested Prerequisite Skills** lists those skills the student should possess before starting the activity.

The **Materials** list contains items needed by each student, unless specified otherwise, to complete experiences.

The **Time** indicates the length of each investigation. The reference to class period represents 55 minutes.

The **Caution** section deals with do's and don't's and should be adhered to closely.

The **Grade Level** is given as a range because many of the activities have been used in several grades.

The **Student Discovery Activities** are the investigations the students do leading to their discovery of the concepts and facts listed in the teacher section and to satisfy the terminal performance objectives listed in the pre-lab.

The **Processes** are listed to show both the teacher and student the types of mental operations required for each step of the student discovery activity section.

Suggestions for Using Discovery Approach

- Be enthusiastic.
- Always encourage the students. Use positive reinforcement. Do not criticize a student's poor thinking efforts. Give recognition to students for making good hypotheses, predictions and conclusions.
- What appears on the surface to be a silly answer may be due to the student's inability to communicate. When investigated further, a silly answer may be full of insight.
- Deliberately encourage students to make guesses.
- Record all student guesses on the chalkboard.
- Encourage the students to recommend those guesses that could be eliminated before the investigation begins.
- Always maintain an atmosphere that it is better to think than not to think.
- Have fun yourself during the students' investigations.
- If an investigation does not produce the product listed in the post-lab section, ask the students if they can determine why. They may learn more from the experience than they would if the investigation conclusions were the same as those listed in the post-lab.
- Do not be hesitant to do an investigation if you don't know all about it. Your students do not expect you to know everything. They enjoy having their teacher learn with them.

John D. Hunt
Editor

OCT 2 0 1980

Establishing a Living Materials Center

A living marine materials center easily can be established in a classroom by purchasing items from a local vendor or from commercial supply houses. A few supply houses are listed below, with address, telephone number and suggested contact. Where possible, living specimens should be obtained from their natural environment--the ocean. For inland schools where this is not possible, a supplier is listed. A 20-gallon, long aquarium is recommended. Other basic items are listed below.

Items	Supply Source	Cost*
30 lbs. crushed coral (2 to 3 mm in size)	Dick Greenfield Carib Sea Inc. P.O. Box 570269 (305) 251-2473	$17.90 per 100 lbs.
or		
30 lbs. crushed dolomite	Southeast Aquatic 15C Royal Drive at Forest Park Atlantic, Georgia (404) 363-4641	Not available
"Instant Ocean"	Mary Jane Boris Aquarium Systems 8141 Tyler Blvd. Mentor, Ohio 44060 (216) 255-1997	$23.00 per 150-gallon aquarium
Live specimens (if not available from the beach)	Paul A. Shave Northeast Marine Environmental Institution P.O. Box 666 Monument Beach Bourne, Massachusetts 02553 (619) 259-4055	Prices vary according to type and quantity of organisms purchased
Underground filter	Local Vendor	$4.00
3/6" Plastic tubing (about 3 feet long)	Local vendor	$ .03 per foot
Air stone	Local vendor	$ .39
Plastic gang valve (to distribute air from pump to filter)	Local vendor	$2.25
Air pump	Local vendor	$10.00
Aquarium top	Local vendor	$7.00

*Summer 1980 prices

A few chemicals also are needed, and may be purchased from any commercial supplier. Two such suppliers include:

Carolina Biological Supply Company
Burlington, North Carolina 27215
(800) 334-5551

Sargent Welch Scientific Co.
5915 Peeler Street
P.O. Box 35445
Dallas, Texas 75235
(214) 357-9381

Allow three weeks for delivery of all items purchased from a commercial supplier.

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What Is It?
(An Inquiry Activity)

Level: 4-12

Pre-Lab

Concept

- Inquiry is the search for ideas to explain facts as well as the search for facts to test and develop explanatory ideas (hypotheses and theories).
- Scientists follow a six-step research or scientific method:
  Define the problem
  Collect information on the problem
  Form a hypothesis
  Experiment to test the hypothesis
  Observe and record data from the experiment
  Draw conclusions

Facts

- Sea anemones are maintained easily in the classroom.
- Sea anemones possess a few observable animal characteristics.

Suggested Prerequisite Skills

- Students must be mature enough to control themselves in a fairly unstructured setting.
- Students must be patient since the organisms are sometimes slow to recover after responding to stimuli.

Materials, Times, Cautions

- Each sea anemone used should be open with tentacles extended in a feeding posture.
- The sea anemones should be attached to the bottom of a 250 ml beaker or similar vessel. The anemones will become attached if removed from rocks and placed in a beaker overnight. They can be removed from the beaker and moved to a new substrate by gently sliding the thumb nail under the pedal disk. This procedure will not harm the organism or the student.

Definition of Terms

Data	All the facts about a particular problem.
Fact	Any observation that many people can make.
Hypothesis	A working idea to be tested that explains the facts.
Inquiry	Investigating a problem; a search or investigation.
Scientific or research method	A logical, orderly way of trying to solve a problem.
Theory	A hypothesis that is repeatedly supported by testing.
Environment	A place where an organism lives.

What Is It?
(An Inquiry Activity)
Student Lab

General Information

What is it? What does it do?

In this activity you are to play the role of Sherlock Holmes, the great detective. Pay close attention to any clues you may find.

Scientists in the process of discovery, like detectives, follow a procedure called the research method which contains the following steps:

1. Define the problem.
2. Collect information on the problem.
3. Form a hypothesis.
4. Experiment to test the hypothesis.
5. Observe and record data from the experiment.
6. Draw conclusions.

In the following study, list everything about the organism (collect data). Form a working idea (hypothesis) to be tested. The simpler the idea (hypothesis), the better. Test the hypothesis to prove or disprove it. You then may want to form a new hypothesis and test it later.

Objective

- To use the scientific method to identify characteristics of this organism.

Materials

- An organism
- A beaker of seawater
- A light source

Processes	Student Discovery Activity
	Follow the directions listed but do not damage the organisms. Obtain a specimen from your teacher. Place the beaker on a paper towel.
Observing	1. Look at the organism and try to describe it. Pay attention to the shape of the body. What does the body appear to be made up of? Describe the shape, number and location of any projections from the body. Are there any openings in the body? If so, how many?
Inferring	2. Write a hypothesis (a working idea to be tested) about the organism.
Inferring	3. Test the hypothesis. What conclusions can be drawn?
Communicating	4. Add a light to the set-up. Write a hypothesis for adding a light source to the organism's environment.
Inferring	5. Test the hypothesis. What conclusions can be drawn?
Communicating	6. Note that the organism is attached to the beaker. Why? Describe the habitat of the organism; be specific.
Inferring	7. Is this organism a plant or animal? Why?

Summarizing	8.	Make a list of all the characteristics this organism possesses in response to sight, feeling, movement. etc.
Inferring	9.	How does this organism react to its environment?
Inferring	10.	Where does this organism live in the marine environment?
Summarizing	11.	List what you have established as fact from testing your hypothesis.
Summarizing	12.	List what you have deduced based on what you found out from testing your hypothesis.
Comparing	13.	How does this organism differ from humans?

What Is It?
(An Inquiry Activity)
Post-Lab

Possible Answers to Questions

The answers will vary for all questions. The answers listed here are for comparison only so students can relate their responses to a "correct" answer.

1. Shape: cylindrical
   Make-up: soft tissue
   End: both ends are not the same; one has projections, the other is attached to the beaker
   Projections: several dozen tapering projections are found around the edge of the upper surface; these can move
   Openings: one opening in the middle of the upper surface
2. Sample hypotheses: The projections will move if touched with a ballpoint pen. The organism will move if poked with a pencil.
3. Answers vary.
4. The animal should not respond to light. (It may have responded to heat if the lamp were too close.)
5. Answers may vary.
6. The organism lives on a type of material that is solid.
7. Organism is an animal because it moves.
8. A sea anemone cannot see and will not respond to light. It has feeling, however, and the tentacles will retract if they are touched. A sea anemone can detach itself and crawl, but this will not be observed within the time frame of this activity.
9. It retracts when disturbed.
10. It lives on hard bottoms.
11. Answers may vary.
12. Answers may vary.
13. Tentacles are similar to human arms, but there are more tentacles than arms.

Discussion

This study should increase the student's ability to both observe and appreciate the basic tenets of the research method of scientific study. By being asked to deduce certain things, the student is required to form hypotheses which may be tested or could be tested later.

Evaluation

This activity should not be evaluated by the total number of right answers, but rather by the responses each student can glean from a mass of confusion.

Follow-Up

- Sea anemone (**Bunodosoma cavernata**) anatomy and feeding activity.

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The Gourmet — a la Crab!

Level 4-6

Pre-Lab

Concept

- Animal feeding behavior

Facts

- Hermit crabs must use their walking feet to search out food sources.
- Hermit crab uses its sense of smell to locate food.
- Hermit crabs prefer certain foods over others when more than one variety is available.
- Hermit crabs display selective behavior when choosing foods.

Suggested Prerequisite Skill

- Given various food sources and a hermit crab, set up an experiment to determine what sense(s) are used to obtain food.
- Given multiple opportunities to observe the behavior of the hermit crab, compare selection responses to different types of foods.
- Given different foods, determine if a crab prefers a certain food.
- Given a hermit crab, determine what sense is most important in food-gathering behavior.

Materials, Times, Cautions

- Preferably each student will conduct an individual experiment; however, teams of two's are permitted.
- Use a plastic pie pan or something similar. **Do not use a metal pan.**
- It is essential that the water be changed after each food has been inserted into the water so one food will not interfere with another.
- This activity will take at least one class period.
- The wood barriers to be used should be tall enough so that the crab cannot see over it. Dark plastic barriers may be substituted.

The Gourmet — a la Crab!
Student Lab

General Information

All animals in nature have a natural desire to search for food to meet their needs for existence. Food preferences vary from organism to organism depending on the needs of each. The hermit crab is a very hardy species of crab and is quite active, thus, its need for a good supply of food. In its natural environment its ability to select food depends on the moment and what is readily available in the area.

Objective

- To determine if there are selective tendencies by the hermit crab to choose its foods.
- To gain knowledge about the eating behaviors of hermit crabs.

Materials

- Hermit crab
- Shallow plastic pan
- Wood barrier to stretch halfway across pan
- Crab foods (frozen shrimp, lettuce, dry dog food)
- Seawater
- Empty plastic pill vial with cap

Processes	Student Discovery Activity
	1. Place plastic pan on your work table and fill with about 5 centimeters of seawater.
	2. Insert wooden barrier so it stretches from the outer edge of the pan inward to the center. Weight it down so it stays in place.
Hypothesizing	3. How do you think a crab will behave if you place a morsel of food somewhere in his experimental environment?
	4. Now place a hermit crab in the pan of seawater on one side of the barrier.
	5. On the other side of the barrier place a small piece of lettuce leaf.
Observing	6. Observe the crab and describe its actions.
Observing	7. How did the crab respond to the lettuce leaf?
	8. Remove the crab from the pan, discard the lettuce leaf and seawater.
	9. Fill pan with fresh seawater again. Place the same crab on one side of barrier and put a morsel of dry dog food on the other side of the barrier.
Observing	10. Allow crab to move about. Describe the resulting behavior of the crab.
Inferring	11. Based on your observations, compare behavior responses to the two food types presented.
	12. Remove crab from pan and discard food and water as before. Place fresh seawater in pan.
	13. Place crab in pan behind barrier.
	14. Insert morsel of shrimp meat on opposite side of barrier.
Observing	15. Allow crab to respond to your situation. Describe the resulting behavior the crab displays.

Inferring	16. Did the crab respond more quickly to any one of the three tests?
Inferring	17. How did the crab respond when you presented the shrimp?
Comparing	18. How does the shrimp morsel compare to the other two foods presented?
	19. Now place the one preferred food in a clear plastic vial.
	20. Remove crab and discard food and water. Replace with fresh seawater.
Observing	21. Replace crab in pan along with food in vial. Observe behavior of crab. Describe what occurs.
Summarizing	22. From what you have observed in the four tests performed, what sense does the crab use when feeding?
	23. Return the hermit crab to its normal habitat and clean up all equipment used.

The Gourmet — a la Crab!
Post-Lab

Possible Answers to Questions

3. Answers will vary. Most will say that the crab will go for the food.
6. Students will observe that the crab will move around, acclimating itself to the environment, perhaps moving in the direction of the lettuce. This may not happen in all cases.
7. Answers will vary.
10. Crab may show some interest in the dog food on the opposite side of the barrier. Answers may vary from experiment to experiment.
11. Results may show that the crabs may respond more to the dog food than to the lettuce. Variations may occur.
15. Crab may show more of a tendency to respond to the shrimp morsel in the water.
16. Answers may vary.
17. Answers may vary.
18. A trend of behavior may develop in the class toward the shrimp.
21. Crab more than likely will not respond with positive behavior toward the vial containing the shrimp.
22. Based on observations, crabs use their sense of smell when feeding.

Discussion

The crabs' behavior may show a positive trend toward shrimp and dog food placed directly in the water since the molecules of these foods dissipate throughout the water, enabling the crab to sense their presence more quickly. The food in the vial will go undetected in the majority of cases as the crab's vision is not that precise.

Evaluation

Students should do well in this activity. Impatience may develop while the crab makes up its mind in responding to the experimental situations, but this is to be expected. All concepts for this activity should be mastered.

Follow-Up

This activity can be modified to use small blue crabs as experimental subjects. Also, this experiment can be conducted under different environmental conditions of light, temperature and salinity.

The Effects of Light, Oxygen and Temperature on the Hatching of Brine Shrimp

Level: 4-6

Pre-Lab

Concept

- Environmental variables and their effects on brine shrimp.

Suggested Prerequisite Skills

- Student must be able to follow directions.

Student Performance Objective

- Given brine shrimp, the student will determine the optimum conditions necessary for life by counting the number of live shrimp in various jars and comparing the results.

Materials, Times, Cautions

Materials

- Six wide mouth quart jars
- Pipette or dip net
- Brown paper bags or black construction paper
- Labels
- Non-iodized salt
- Air hose or stone and pump
- Dried yeast
- Aged tap water
- Salad oil
- Refrigerator

Time

This activity requires 14 days to complete.

Cautions

It will be essential to insure that no contamination occurs. There must be a specific pipette or dip net for each jar. It is suggested that these have a readable label attached that is color coded to match the jar. To put the air pump into the refrigerator, merely put it on the shelf, run the cord out the door to an extension cord and shut the door. The gasket will take care of this.

The Effects of Light, Oxygen and Temperature on the Hatching of Brine Shrimp Student Lab

General Information

Just as you grow best with proper food, light, exercise and rest, so do brine shrimp. By putting a specific number of eggs in a jar and checking to see which jar has the greatest number of live shrimp compared to the number of unhatched eggs, you can determine the effect of the condition you have created on the shrimps' development. You will be determining the effect of oxygen or lack of it on one set; on another set, the effect of light; and in the third set, the effect of temperature.

Objective

- To determine the best condition for brine shrimp life.

Materials

- Six wide mouth quart jars
- Pipette or dip net
- Brown paper bags or black construction paper
- Labels
- Non-iodized salt
- Air hose or stone and pump
- Dried yeast
- Aged tap water
- Salad oil
- Refrigerator

Processes	Student Discovery Activity
Communicating	1. Six wide mouth quart jars should be labeled and color coded with pipettes to match. The labels should be as follows: a. Oxygen (by air pump). b. No oxygen (sealed with salad oil on top). c. Light (placed near the window). d. No light (placed in a black paper wrapped jar in the area away from the window but in the same temperature range). e. Warm (placed in a warm place and wrapped in black paper). f. Cold (placed in the refrigerator).
Measuring	2. Pour tap water that has been aged 24 hours into each quart jar and add 2 teaspoons of salt.
Measuring	3. Add 20 shrimp to each jar. Make sure that you count these accurately.
	4. Do the following to each jar: a. Jar A, **Oxygen**, place in light with an air hose connected to the pump. b. Jar B, **No Oxygen**, place 2 tablespoons of salad oil on top of the water and place in the light (without an air pump hose). c. Jar C, **Light**, place in the light with an air hose connected to pump.

d. Jar D, **No Light**, place in a black paper wrapper in a dark place with an air hose attached to a pump; put in an area with about the same temperature range as Jar C.
e. Jar E, **Temperature Warm**, wrap the jar in black paper and place in a warm spot with a hose from the air pump.
f. Jar F, **Temperature Cold**, wrap the jar in black paper and place in a refrigerator with a hose from the air pump.

Observing 5. These jars should be observed daily for about two weeks. Record the date on the data sheet. Remember to use the same net or pipette for each jar each day.

Measuring 6. Feed the shrimp daily with a grain of dry yeast per jar.

7. Record the data on the following chart.

NUMBER OF SHRIMP ALIVE ON	OXYGEN	NO OXYGEN	LIGHT	NO LIGHT	WARM	COLD
DAY 1						
DAY 2						
DAY 3						
DAY 4						
DAY 5						
DAY 6						
DAY 7						
DAY 8						
DAY 9						
DAY 10						
DAY 11						
DAY 12						
DAY 13						
DAY 14						

Observing 8. Which light and dark jars had the most live shrimp?

Observing 9. Which oxygen and no oxygen jars had the most live shrimp?

Observing 10. Which cold and warm jars had the most live shrimp?

Observing 11. Of all six, which had the highest number of live shrimp at Day 3 and Day 14?

Observing 12. Which one jar had the lowest number of live shrimp?

Inferring 13. Why do you think this one had the lowest number?

Applying 14. Of all the things that you need to stay alive--oxygen, light, water and food--which one can you do without the longest?

Applying 15. Which one can you do without the least?

Applying 16. How are we like shrimp?

The Effects of Light, Oxygen and Temperature on the Hatching of Brine Shrimp Post-Lab

Possible Answers to Questions

8. Probably the light jar had the most live shrimp.
9. Probably the oxygen jar had the most live shrimp.
10. The jar that maintained a temperature around 21°C.
11. Probably the light jar.
12. Probably the no oxygen jar.
13. Animals must have oxygen to survive.
14. Light.
15. Oxygen.
16. Answer will vary.

Discussion

Ask students to share their responses and continue the discussion on how light, oxygen and temperature are important for survival. Expand on the responses to questions 14 through 16.

Evaluation

Allow time to observe and record information on the brine shrimp. Have groups discuss and compare their results. Discuss the differences that occur, even though they followed the small procedure.

Follow-Up

- The salt factor in raising brine shrimp activity.
- The baby shrimp nursery activity.

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Gulp, Gulp Goes the Killifish

Level: 4-8

Pre-Lab

Concepts

- Fish breathe by gills.
- The respiration rate varies according to certain stimuli.

Facts

- The operculum covers gills in bony fish.
- Absorbing oxygen from water enables fish to breathe.

Suggested Prerequisite Skills

- Student must be able to handle living material.
- Student must be able to handle a hot plate or bunsen burner.
- Student should have skills in collecting and recording data.

Student Performance Objectives

- Given several killifish, the student will determine the fishes' respiration rate.
- By watching more than one killifish, the student will discover that different environmental factors change the respiration rate.

Materials, Times, Cautions

Materials

- Aquarium
- Killifish (could substitute the Pinfish, Gambusia, etc.)
- Glass rods
- Net
- Small enamel pan
- Saltwater
- Beaker tongs or hot pads
- Ice bath
- Two different size beakers

Time

This activity will take at least one class period and can be expanded by trying different stimuli.

Cautions

- Warn students about overheating or overcooling fish; 120°F or 48°C is hot enough, 41°F or 5°C is cold enough.
- Be sure to follow the basic TEA safety standards.

Gulp, Gulp Goes the Killifish
Student Lab

General Information

Fish absorb oxygen from water through gills. Water enters the mouth, passes over the gills and passes out through the gill covering called the operculum. Fish need oxygen to provide energy for their life activities. When they are more active they require more oxygen and must take in more.

Objective

- To gain knowledge of the various respiration rates. a killifish is subjected to different environmental factors

Materials

- Aquarium
- Killifish
- Glass rod
- Net
- Smali enamel pan
- Beaker tongs or hot pads
- Ice bath
- Safety goggles
- Two different size beakers
- Saltwater

Processes	Student Discovery Activity
Observing	1. Observe the fish in the aquarium. **Do not** disturb the aquarium in any way.
Measuring	2. Determine the number of operculum beats per minutes (count them for 15 seconds and multiply by four).
Communicating	3. Do this at least five different times and take the average.
	4. With a glass rod, disturb the water slightly (**do not touch the fish**).
Measuring	Count the operculum beats — average several times.
Communicating	Record answer in Table 1.
	5. Prod the fish gently (do not harm it) for about one minute so that it remains active.
Measuring	After a minute has passed, count the operculum beats.
Communicating	Record your answer in Table 1.
Inferring	6. How do you think the respiration rate of an active fish is affected?
	7. Remove the fish from the aquarium by using a net.
Observing	Place the net containing the fish in an enamel pan and observe.
Measuring	Count the operculum beats.
Communicating	Record your result in Table 1.

Table 1 **Respiration Rate**

Condition of water or fish	Operculum beats per minute
Undisturbed fish	
Disturbed water	
Disturbed fish	
Fish in air	

Inferring 8. What do you think will eventually happen?

9. Put the fish back in the aquarium. Wait two or three minutes.
Measuring Count the operculum beats.
Communicating Record your answer on your paper.

10. Place the fish in a beaker of water from the aquarium.
Measuring Determine the temperature of the water in the beaker.
Communicating Record your response in Table 2.

11. Increase the temperature of the water slightly with a hot plate or burner. **Do not** exceed 48°C (120°F).
Measuring Count the operculum beats.
Communicating Record your response in Table 2.

12. Remove the beaker from the heat source.
Measuring Count the operculum beats as the water returns to its original temperature.
Communicating Record answer in Table 2.

Table 2 **Respiration Rate in Heated Water**

Temperature	Operculum beats per minute

13. Return the fish to the original aquarium.
14. Obtain **another** fish and place it in a beaker of water from the aquarium.
15. Cool the beaker of water by placing it in an ice bath (prepared by making an ice slush in a larger beaker).
Measuring Determine the operculum beats as the water cools.
Take five different readings.

Communicating Record your results in Table 3.

Table 3 Respiration Rate in Cooled Water

Temperature	Operculum beats per minute

Graphing 16. Graph all your data.

Inferring 17. What effect does a change of temperature have?

Inferring 18. Why is it advantageous to the fish to be more active when it is disturbed?

Hypothesizing 19. What do you think will happen to a fish left in air?

20. Return the fish to its proper environment at the conclusion of the activity.

Gulp, Gulp Goes the Killifish
Post-Lab

Possible Answers to Questions

- Student answers to the questions will vary.
- Results listed in Tables 1-3 will vary.

Discussion

The effects should be predictable when the fish is disturbed. The fish is able to escape danger by increasing its activity, but it needs more oxygen. Heating water not only increases the metabolism of all marine organisms, but also drives oxygen out of the water and the fish has to work harder to get the oxygen it needs. Van't Hoff's law states that metabolism increases twofold for each 10°C rise in temperature. Cooler water holds more oxygen.

The concept of a fish "drowning" in air also should be discussed.

Evaluation

You should expect reasonable success with your students. Many of the students' responses will vary due to their reading a thermometer and counting operculum beats but this is to be expected.

Follow-Up

- Many other stimuli can be used such as changes in pH and salinity of the water (some fish utilize gills in salt excretion).
- Other types and sizes of fish can be used.
- Determine if different fish have quicker or slower recovery times, etc.
- What are the conditions in nature which have favored these adaptations?

Water Current

Level: 4-8

Pre-Lab

Concept

- Currents influence the distribution of living organisms in the sea.

Facts

- Differences in density cause current.
- Density varies with temperature.
- Density varies with salinity.

Suggested Prerequisite Skills

- Students should have an understanding of density.
- Students should be skillful in handling glassware and reading instructions carefully.
- Students should know how to use a hydrometer to determine density.

Student Performance Objectives

- Given several solutions, the student will prepare different salinities.
- Given different salinities, the student will demonstrate the movements of water.

Materials, Times, Cautions

Materials

- Small aquarium or pyrex baking dishes
- Salt
- Water
- Dropper
- Small piece of plastic, cardboard, metal or glass that can divide the dish into two sections
- Spoons
- Small mixing bowls
- Beakers
- Food color

Time

This activity should be completed in one class period

Cautions

Instruct students to place a divider at the bottom of the aquariums or baking dishes. This can be done by fastening the divider with several strips of clay. Caution students about using too much clay.

Water Current
Student Lab

General Information

Currents help ships save many days on long voyages. These same currents determine, to large extent, where marine organisms live. Several factors can cause currents in the ocean: differences in densities, temperature, and differences in salt content or salinity. The latter currents are commonly referred to as salinity currents.

Objectives

- To demonstrate movements of water caused by differences in salinity.

Materials

- Several aquariums or pyrex baking dishes
- Salt
- Water
- Dropper
- Food coloring
- Spoon
- Beakers or small mixing bowls
- Small pieces of glass, metal, plastic or cardboard as a divider

Processes	Student Discovery Activity
	1. Place a divider across an aquarium or baking dish.
	2. Make sure it fits tightly against the bottom and the two sides. Seal the bottom of the divider with clay. Make sure there are no holes.
Measuring	3. Add salt to water until it is about 3 percent (30 g per 1000 ml) salt.
	4. In marine science salt content is expressed in parts per thousand so your 3 percent water will be 30 o/oo. Ocean salinity is around 35 o/oo.
	5. **Work with a partner.**
	6. Each person will add one beaker of water to the dish or aquarium. One adds clear water on one side of the divider, while the partner adds saltwater to the opposite side.
	7. When the water has been added on both sides of the divider, **slowly** and **carefully** lift out the divider.
	8. Disturb the water as little as possible.
Observing	9. Which water mass has the greatest density?
Predicting	10. What do you think **will happen** to the water masses?
Observing	11. What did happen?
Inferring	12. Why do you think the water masses moved as they did?
Designing an investigation	13. Design an experiment to show that temperature can cause currents.

14. All water in the polar regions moves toward the equator.

Applying 15. Do you think water from the polar regions would move on the surface of the ocean?

16. Some fish can only live in cold water, yet they live in the equatorial oceans.

Applying 17. Why is this possible?

Water Currents
Post Lab

Possible Answers to Questions

9. Saltwater has greater density (more particles per volume).
10. Students will usually guess that there will be a mixing of the colors. Also, the colored salty water will move faster.
11. The "heavier" denser colored water sinks below the "lighter" less dense clear water.
12. Refer to 11.
13. The clear water can be warmed and the colored water cooled with ice or vice versa.
15. Polar water sinks and moves toward the equator, replacing the lighter, warmer water which rises.
17. A fish with a narrow range of tolerance for temperature change and adapted to cold water can be found in the cold waters even at the equator because the cold waters will be found at the bottom.

Discussion

- Most of the major surface currents of the world begin in warm areas where water of less density has a higher surface temperature than areas of higher density.
- As these warmer waters move they are deflected by the rotation of the earth.
- The greater the density gradient (change of density in a given distance), the faster the related current.
- The direction of the wind determines the course of many of the surface currents, but density differences rate second as the cause for movements of large masses of water.
- Currents influence the climate of many coastal regions. For example, the warm waters of the Gulf Stream in the North Atlantic are blown over the British Isles and Europe warming these countries while Labrador and North Canada, at the same latitudes, are cold frigid areas. Reykjavik, Iceland, has a higher average winter temperature than New York City. The west coast of the United States is cooled in summer by the cold California current and warmed in winter by the Davidson current from the south. As a result, the range of temperature is small.

Evaluation

Students should expect success in completing this activity. The concept should be mastered.

Follow-Up

- Other factors which cause currents can be demonstrated. For temperature, a fan can be directed over the surface of a container of water and dye introduced slowly into the water so that movement can be seen.
- What might happen if temperature and salinity were both involved at the same time, such as low temperature (high density) water with a low salinity (low density)?

Embedding Sealife

Level: 4-8

Pre-Lab

Concept

- Embedding in plastic

Facts

- Various forms of sealife may be preserved in plastic to increase their use time for studies.
- Casting plastic is a chemical that comes as a liquid and can be turned into a solid.
- Catalyst is a chemical substance that causes a plastic liquid to harden into a solid.
- Various grits of wet sandpaper are used to produce a shine on a hardened plastic.
- Specimens of marine life, cast in plastic, can be used for study over extended periods of time.

Suggested Prerequisite Skills

- Student must be able to measure volumes of liquids.
- Student must be able to read and follow directions closely.
- Student needs to be briefed in the use of plastics for embedding and appropriate cleanup.
- Student needs to be aware that water will not dissolve casting plastic in cleanup operations, and that acetone must be used.
- Student must employ proper safety measures in removing cast from a glass mold.

Student Performance Objectives

- The student will select an appropriate marine specimen to embed in plastic.
- Given the appropriate chemicals, the student will learn to catalyze liquid plastic to a hardened form.
- Using a specimen of known size, the student will select a casting mold large enough to accomodate the specimen to a clearance of 5mm on all sides.
- Given the proper grits of wet paper, the student will grind a casting to a finished shine.

Materials, Times, Cautions

Materials

- Dry embedding specimen
- Liquid casting plastic
- Plastic catalyst
- Mold (to hold plastic & specimen)
- Mixing container (unwaxed paper cups)
- Mixing stick
- Small measuring cup
- Acetone (for cleaning up)
- #220 grit wet sandpaper
- #320 grit wet sandpaper
- #600 grit wet sandpaper
- Rubbing compound
- Felt board
- Forceps

Time

This lab experience will take more than one day (up five days perhaps) depending on your students.

Cautions

- You will need to secure liquid casting plastic and hardening catalyst from a local handicraft shop or from your commercial science supplier. Plan to get enough for one casting for each student.
- Casting plastic will not harden without the catalyst added to it. The plastic heats up when catalyst is added. This is normal.
- Water and soap will not clean up utensils used with plastic, so use disposable, unwaxed paper cups. Acetone can be used to clean up forceps, etc.
- For specimens, recommend that students start with small shells, sand dollars, etc.
- Dust is a big problem, so all hardening plastics must be covered with "paper tents" as dust covers.

Embedding Sealife
Student Lab

General Information

Organisms that live in the sea display a myriad of designs, each of which is unique in its own special way. Many are discrete and precise in geometric form while others are as shapeless as possible, to avoid detection and consequent predation by higher forms of life. Many of these forms are delicate and last only a short period of time. Thus, man is unable to always share in their beauty unless these forms can be preserved.

Modern-day liquid plastics, which harden to a solid, allow us to capture the natural beauty of many forms of marine life. Dry marine specimens can be immersed in catalyzed casting plastic in a definite form and hardened into a beautiful accent piece which one can use for study and can admire for many years to come.

Objectives

- To develop an appreciation of the natural beauty in marine life.
- To understand how liquid styrene plastics solidify in a chemical reaction.
- To prepare marine specimens for plastic embedding.
- To make a plastic casting containing a form of marine life.

Materials

- Dry embedding specimen
- Liquid casting plastic
- Plastic catalyst
- Mold (to hold plastic & specimen)
- Mixing container (unwaxed paper cups)
- Mixing stick
- Small measuring cup

- Acetone (for cleaning up)
- #220 grit wet sandpaper
- #320 grit wet sandpaper
- #600 grit wet sandpaper
- Rubbing compound
- Felt board
- Forceps

Processes

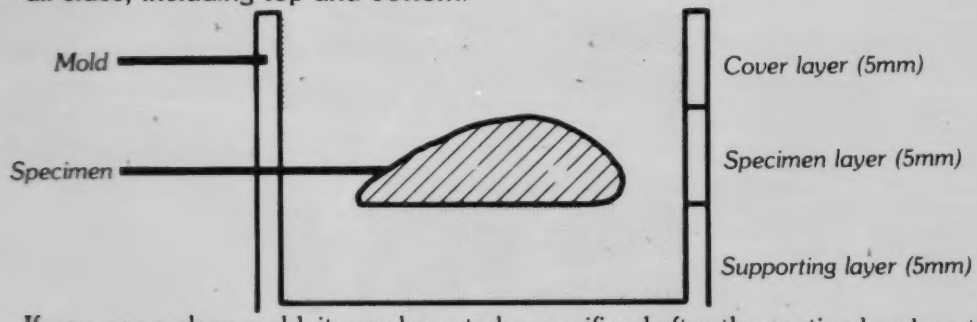
Student Discovery Activity

1. Select a dry marine specimen you would like to preserve in plastic (small mollusk shell, sand dollar, or dry crab molt case is ideal).
2. Place in a small cup.
3. Pour enough uncatalyzed casting plastic over the specimen to cover it so that air bubbles will escape. Leave overnight.

Communicating 4. List some of the physical properties of the casting plastic you observed in #3 above.

Predicting 5. Why is it good to get all of the air bubbles expelled from your specimen?

6. Prepare your mold. Make sure it is clean and dry. Many objects may serve as a mold, such as glass dish, tin can, small jar. The best to use is a plastic mold from a handicraft store. Pick one that will clear your specimen at least 5mm to 1 cm on all sides, including top and bottom.



If you use a glass mold, it may have to be sacrificed after the casting hardens to remove the cast intact.

Measuring 7. In a clean paper cup, pour enough plastic to fill your mold 1/3 full. Add the needed catalyst to your plastic and stir. (See container label of the plastic you are using for correct amount.)

8. Pour mixture into mold and cover with a "paper tent" until the mixture gels. Leave overnight. Leave mold on a level surface. (If your lab has a gas hood, place mold inside so gases may escape.)

Observing 9. After the catalyst was added, what evidence was there the plastic was beginning to gel?

10. After the bottom layer has gelled, use forceps to transfer your specimen from the soaking plastic to your mold. Drain off excess plastic from your specimen before you place it in the mold. Position your specimen in the center of the mold.

11. In a clean paper cup, pour enough plastic to cover your specimen in the mold. Add the needed amount of catalyst and stir thoroughly. Pour mixture over your specimen until it is covered (roughly 1/3 of the height of your mold). Cover mold with paper tent and allow to gel.

12. After specimen layer hardens prepare to pour a top layer to fill out the upper 1/3 of your mold. Mix up the necessary plastic and pour over the specimen layer to fill the mold. Set aside to dry and gel, covered with a paper tent.

13. Cure the mold in a light-bulb oven for a few hours at about 140°F.

14. Allow mold to cool to room temperature and remove the cast. It may be necessary to tap the mold against a board. Sometimes a glass mold may have to be broken to remove the cast. If so, be careful not to cut yourself with the broken glass.

15. The cast is now ready to use if outer surface is smooth, or if rough, to finish by grinding. To grind, lay a sheet of #220 grit wet sandpaper on a smooth, wet surface so the paper adheres to the surface. Grind all surfaces of your cast with a back-and-forth motion. Keep the cast wet and check the degree of grind often.

Observing	16.	Describe the appearance of the surface that you have just been grinding.
	17.	When all surfaces are smooth, switch to #320 grit paper and repeat the same process as in step 15 above.
	18.	When smooth again, switch to #600 grit paper and grind until you get a slight satin sheen on all surfaces.
	19.	Lay your cast on a wet felt board which has a small amount of rubbing compound spread on it. Rub the cast back and forth on felt until the cast shines. Keep the felt board wet.
	20.	If extensive scratches remain on the surface, repeat steps 15, 17, 18 and 19. The finished cast should have a brilliant shine.
Observing	21.	Describe the finished product.
Communicating	22.	List the major problems you encountered in the entire process.
Inferring	23.	What measures could you take to improve your finished product?

Embedding Sealife
Post-Lab

Possible Answers to Questions

4. The plastic has a very strong odor, appears to be colorless and clear and seems syrup-like.
5. It is good to get all the air bubbles out so no bubbles will appear in the finished casting when the specimen is embedded in the mold.
9. After about 10 or 15 minutes, the catalyzed plastic begins to heat up, indicating that a chemical reaction is taking place in the mixture.
16. The surface of the cast appears to be translucent and waxy-white in appearance.
21. The finished cast will appear highly polished on all surfaces and transparent to light. The specimen in the cast is clearly visible in all detail. (Answers to this question will vary from student to student).
22. Answers will vary. Some typical problems may include: too many scratches in the surface; not pouring enough plastic over the specimen to completely cover it; did not have mold level while plastic hardened; dust got into the plastic as it hardened, etc.
23. Answers will vary.

Discussion

As you work through the steps in this lab, you will see that time is important in producing a finished product. You will see many skills being developed by each student as the activity comes to an end. Students quickly will realize the importance of extra special care in finishing out the cast.

Evaluation

Given ample time, you should expect many excellent casts to be finished. Some will not turn out so well, but that can be expected. Encourage all students to complete their cast, regardless of the perfection. Finished casts should have a high shine and no scratches.

Follow-Up

This activity is an introduction to plastic embedding and should serve as a stimulus for working with more difficult specimens. Commercial science supply companies, as well as handicraft stores, have directions for embedding wet specimens, such as small fish and alcohol preserved specimens, and embedding stained and colored sea specimens.

Stretched Skin

Level: 4-8

Pre-Lab

Concepts

- Fish have fins.
- Fins are used for different functions.

Suggested Prerequisite Skills

- None

Student Performance Objective

- Given a fish, the student will identify different types of fins and list their functions.

Materials, Times, Cautions

Materials

- Fish in an aquarium.

Time

- One class period of 50 minutes.

Cautions

- None

Stretched Skin
Student Lab

General Information

Many of the bony fish are well-adapted for swimming by having a streamlined body and a well-developed tail. Wave-like motions from the head to tail propel the fish's body along with the muscles increasing and decreasing in size along the body. Fins have different purposes, however.

Objective

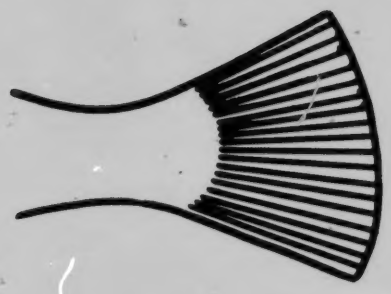
- To observe the different functions of fins.

Materials

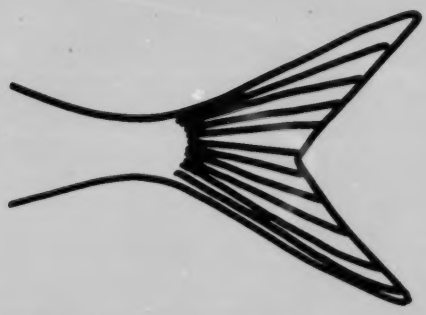
- A live fish in an aquarium

Processes		Student Discovery Activity
Observing	1.	Observe a fish in an aquarium.
Hypothesizing	2.	What do you think is the function of the fish's **back** fin?
Observing	3.	What is its function?
Observing	4.	What is the purpose of a **tail** fin?
Hypothesizing	5.	Some fishes possess an **anal** fin. What do you think is its purpose?
Observing	6.	The paired **pelvic** fins are found on the left and right side of the body of the fish.
Communicating	7.	List two functions of the pelvic fins.
	8.	**Pectoral** fins, also paired, are usually located on the side of the body near the fish's head.
Hypothesizing	9.	What do you think is the function of the pectoral fin?
Communicating	10.	Draw a picture of the fish and label each fin with one of the underlined words.
Interpreting data	11.	According to the type of tail fin your fish has, could the tail be for: swimming between rocks and crevices; fast, short bursts of speed; fast speeds over long distances; or very fast speeds over very long distances?

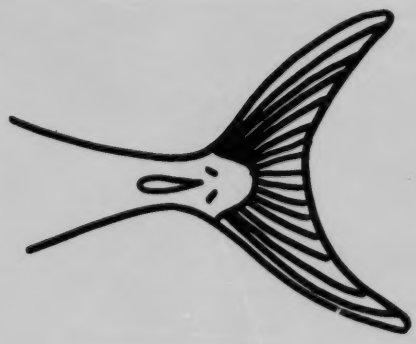
Tail for swimming between rocks and crevices



Tail for fast, short bursts of speed.



Tail for fast speeds over long distances



Tail for very fast speeds over very long distances

Applying

12. After choosing the tail fin that matches the fish you have in your aquarium, write down the name of a fish for each of the remaining tail types.

Stretched Skin
Post-Lab

Possible Answers To Questions

2. Answer will vary.
3. The back or dorsal fin is used for protection and swimming or acts as a stabilizer.
4. The tail or caudal fin is used to propel the fish.
5. Answer will vary. It is used for movement.
7. The pelvic fin is used for stopping, stabilizing or sculling.
9. Answer will vary. They are used primarily for turning and sculling.
11. Answer will vary.
12. Answer will vary.

Discussion

In what kind of natural habitat does your fish live? Was your fish caught where there were rocks, weeds, grass, mud or sand on the bottom? Was the water deep or shallow? Did it live in a bay, under a pier, near a sunken tree, etc.? Identify the appendages on other animals similar to fish fins.

Evaluation

Name five functions of fish fins. Draw and label a typical fish and its fins.

Follow-Up

- Look up the eel, grouper, tarpon and tuna in a fish identification text and draw the different fins.
- Choose four other types of fish and draw and label their fins. Notice the difference in the number of fins and their placement.

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The Salt Factor in Raising Brine Shrimp

Level: 5-8

Pre-Lab

Concept

- Brine shrimp and water

Suggested Prerequisite Skill

- Student must be able to follow directions.

Student Performance Objective

- Given shrimp eggs, the student will determine the amount of salinity needed to hatch a high number of brine shrimp.

Materials, Times, Cautions

Materials

- 4 liter-size jars
- Aged water (leave tap water sitting for 24 hours)
- Salt, non-iodized
- Shrimp eggs
- Dip net or pipette
- Air pump and hose setup (See illustration in "The Culturing of Brine Shrimp Larvae" activity)

Time

This activity will take three days to complete.

Cautions

"Saltwater algae and bacteria are the natural foods of brine shrimp. Under artificial conditions, the best way to provide food is to add powdered yeast two or three times a week to produce a good general population of bacteria. Mix a pinch of yeast in a little water, and float a small quantity on the surface of the culture. Too much yeast will kill the brine shrimp. Apart from food, oxygen is an essential requirement for successful maturation of brine shrimp, so artificial aeration is desirable. " (Orlans)

The development of brine shrimp from eggs to mature animals is dependent on the salinity of the water in which the shrimp are grown. You may add to the number of salinity tests by increasing or decreasing the amount of salt in the quart jar of aged water. Once again, be sure you do not use iodized salt except as a test.

The Salt Factor in Raising Brine Shrimp
Student Lab

General Information

The net must be rinsed thoroughly and dried or the salt will become concentrated enough in the net to affect your results. In addition, be sure that you use the same number of eggs in each jar.

Objectives

- To determine the effect of the amount of salt in the incubation water by counting the number of shrimp that hatch.

Materials

- At least 4 jars of liter size
- Aged water (24 hours from the tap)
- Salt, non-iodized
- Salt, iodized
- Shrimp eggs
- Dip net or pipette
- Air pump and hose setup

Processes **Student Discovery Activity**

1. Label jars as follows: Tap Water-No Salt; 2 teaspoons Salt; 2 teaspoons Iodized Salt; 2 tablespoons Salt. You may use other jars with other amounts but be sure you label accordingly.

Measuring 2. Put the specified amount of salt into the jars and fill with aged tap water. Stir thoroughly. Place in a well-lighted, warm place.

3. Place exactly 24 eggs in each jar and insert the air hose in each.

Communicating 4. One day later, record the number of hatched shrimp by looking in the jars.

Communicating 5. Check again the second, third, and fourth days and record on data chart.

Communicating 6. Compare the results and answer the questions.

DATA CHART FOR SALINITY FACTOR				
	TAP WATER NO SALT	2 TEASPOONS IODIZED SALT	2 TEASPOONS SALT	2 TABLESPOONS SALT
NUMBER OF EGGS HATCHED 1 DAY LATER				
2 DAYS LATER				
3 DAYS LATER				

Observing	7.	Which jar had the **most** eggs hatched?
Observing	8.	Which jar had the **least** eggs hatched?
Predicting	9.	Did the amount of salt have any influence on these results?
Inferring	10.	How did salt influence the results?
Predicting	11.	Did iodine in the salt influence the eggs?
Inferring	12.	How did iodine influence the results?
Inferring	13.	Iodine is used on cuts and wounds to stop bacteria from growing. How does this affect eggs from shrimp?
Observing	14.	Which jar had retarded egg development?
Inferring	15.	Why do you think this happened?
Designing an investigation	16.	You may choose to take varying amounts of salt (slightly above the amount and slightly below the amount) and check to see if your answer for question 14 is correct.

The Salt Factor in Raising Brine Shrimp
Post-Lab

Possible Answers to Questions

7. Jar with two teaspoons of salt.
8. Jar with tap water.
9. Yes
10. Answer will vary.
11. Yes
12. Answer will vary.
13. Answer will vary.
14. Jar with iodized salt.
15. Answer will vary.

Discussion

The following paragraph could be used to stimulate discussion. "Eggs of the Brine Shrimp wash up on the shores of the bodies of water in which Brine Shrimp live. At the Great Salt lake, they are moved around with a bulldozer. These eggs are dried, processed and sold for hatching all over the world. They are clean, wholesome, enemy-free food which has been found to be one of the best diets ever for growing fry. Before Brine Shrimp were fed to fry, the percentage raised was 25 percent. Commercial Brine Shrimp hatcheries recommend that the water be kept between 75°F and 90°F with 85°F optimum with hatching complete in 24 hours. They've learned that the water needs movement to keep the eggs from settling and asphyxiating the bottom ones as they are hatching (the purpose of a vigorous air stone). Therefore a wide bottomed container is most desirable as is an environment of no crowding." (Schneider and Whitney)

Evaluation

- Allow time to observe and record the information on the brine shrimp.
- Have groups discuss and compare their results.
- Discuss the differences that occur, even though students followed the same procedure.

Follow-Up

- The Baby Shrimp Nursery activity.
- The Culturing of Brine Shrimp activity.
- The Effects of Light, Oxygen and Temperature on the Hatching of Brine Shrimp activity.

References

Connell, R.F.O. **The Fresh Water Aquarium**, a complete guide for the home aquarist. St. Petersburg, Florida: Great Outdoors Publishing Co., 1971.

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The Baby Shrimp Nursery

Level: 5-8

Pre-Lab

Concept

- Brine shrimp development

Suggested Prerequisite Skill

- Student must be able to follow directions.

Student Performance Objective

- Given the developmental steps of the brine shrimp's maturation, the student will recognize the processes and procedures to support this maturation.

Materials, Times, Cautions

Materials

- Paper towel
- Shallow plastic, porcelain or glass pan
- Shrimp eggs
- Dowel or glass rod to support paper towel
- Synthetic or commercial saltwater mix
- Medicine dropper
- Dried yeast

Time

A few days will be required to observe the birth and growth of brine shrimp.

Cautions

Follow the hatching procedure described in The Culturing of Brine Shrimp Larvae activity. When you buy the shrimp eggs at a pet store, do not get those that have salt mixed with them. Follow the paper towel method described so students can observe the steps of development more closely.

The Baby Shrimp Nursery
Student Lab

General Information

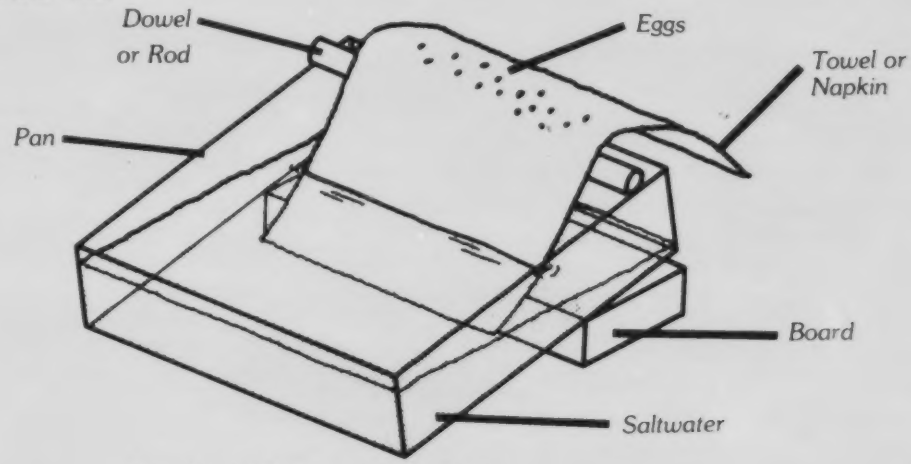
Brine shrimp are small relatives of other crustaceans like the crab and lobster. When fully grown, they are about a centimeter long and can be observed with a hand lens or in greater detail with a microscope. To see these interesting animals in greater detail, you will need to use top lighting.

Objective

- To observe the development of the brine shrimp's growth from egg stage to adult.

Materials

- Paper towel
- Shallow plastic, porcelain or glass pan
- Shrimp eggs
- Dowel or glass rod to support the paper towel
- Synthetic or commercial saltwater mix
- Dried yeast
- Medicine dropper



Processes	Student Discovery Activity
Observing	1. Take a few dried brine shrimp eggs from the jar. Observe them with a hand lens and then under the microscope. Notice their indentation. Watch this as the eggs soak up the solution of salty water.
Observing	2. Be sure you sprinkle the eggs on the raised paper towel and not in the water.
Observing	3. Make sure that the water moves through the whole towel.
Observing	4. Additionally, prop up one end of the tray to make sure that the paper absorbs water from a reservoir.
Observing	5. Use a hand lens to examine the development of the shrimp which should start hatching in about 6 hours. Start examining these shrimp in about an hour to observe the hydration of the egg.
	6. Top lighting will aid this, but be sure you do not dehydrate the paper with excess heat from the lamp.

Observing 7. Eggs will start to split open in 5 to 8 hours after they are placed on the wet towel. You can see a shrimp pushing its way through the crack in the egg. This shrimp is the "nauplius" and is usually enclosed in clear capsule. After squirming free of the egg, you will notice the thin covering and a "red eye spot" as well as leg-like antennae.

Observing 8. As it develops the shrimp will have 11 pairs of real legs. The antennae's movement helps the shrimp to breathe and move out of the clear capsule within 18 to 24 hours after the egg was put into the water. The three pairs of antennae move the animal about like oars in a pond.

9. The shrimp is a fast swimmer and will need to be slowed down. To do this you must remove excess swimming water.

10. Using a medicine dropper, squeeze all of the air out.

11. Bring the open end near the shrimp.

12. Release your squeeze as you bring the bulb near shrimp and the shrimp will be sucked up in the dropper.

13. Squeeze the shrimp and some of the water in the middle of a microscope slide.

14. Soak up some of the water with a bit of the napkin. The shrimp can now wiggle but not swim.

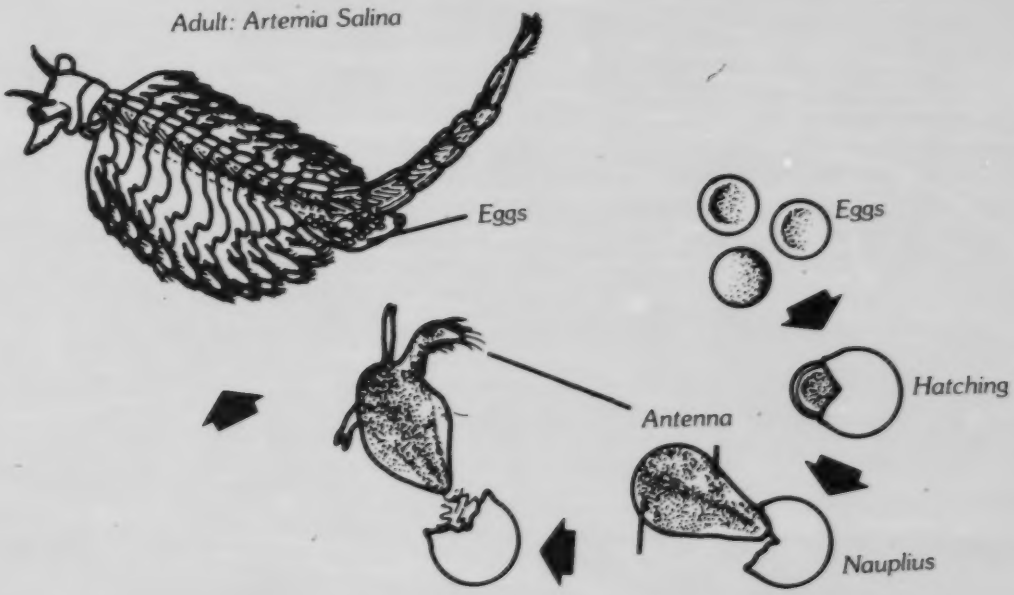
Observing 15. Look at it first with a hand lens, then with the low power of the microscope. Note the size.

Observing 16. Watch the shrimp over the next few days and make drawings of them.

Observing 17. Remember that they shed their skins two or three times as they grow. You may even keep them alive until they produce eggs.

Measuring 18. Try to keep only a dozen shrimp to a liter of water.

19. To keep the shrimp alive, remember that they will need a small piece of dried yeast a day and air bubbling through their nursery.



Observing	1.	How large are the shrimp eggs in mm?
Comparing	2.	How does a dry egg compare with one that has been wet an hour?
Inferring	3.	Why was salt added to the water for the shrimp to hatch?
Inferring	4.	How do you think motion of the antennae assists the animal in breathing?
Inferring	5.	Why is the brine shrimp likely to die when it is taken out of water?
Predicting	6.	The brine shrimp is small. How big do you think the shrimp's food is?
	7.	Put some yeast into a small amount of water and take out a drop of water and place it on a slide under a microscope.
Communicating	8.	Draw a picture of what you see.
Inferring	9.	Why do you suppose you should keep only a dozen shrimp to a liter of water?
Applying	10.	Why are scientists predicting not only an energy shortage, but a famine?

The Baby Shrimp Nursery
Post-Lab

Possible Answers to Questions

1. One mm
2. Shrivelled up
3. Answer will vary.
4. Answer will vary. Helps shrimp to breathe and to break out of its clear covering.
5. Answer will vary.
6. Just as small
9. Overpopulation and eventual death.
10. Overpopulation and not enough natural food to go around.

Discussion

The following paragraphs could be used to stimulate discussion. "Each egg is about 1.5 mm. It is shaped like a teacup and appears hollow with a distinct rim around it. After the egg has soaked in water, it becomes round but still shows the rim as a circle about the egg although the circle is depressed.

"The egg cracks at right angles to the depression and the crack extends only as far as the depression. The shrimp nauplius emerges through the crack and is enclosed in a thin transparent sac which fills the crack and prevents water from entering the egg. The shrimp inside the sac emerges and the egg closes. The depression has acted as a hinge. The shell, now empty, floats like a ball, holding onto the sac below until the nauplius has ruptured the sac and swum away." (Schneider and Whitney)

Evaluation

- Allow time to observe and record information on the brine shrimp.
- Have groups discuss and compare their results.
- Discuss the differences that occur, even though they followed the same procedure.

Follow-Up

- The Culturing of Brine Shrimp Larvae activity.
- The Salt Factor in Raising Brine Shrimp activity.
- The Effects of Light, Oxygen and Temperature on the Hatching of Brine Shrimp activity.

References

Connell, R.F.O. **The Fresh Water Aquarium**, a complete guide for the home aquarist. St. Petersburg, Florida: Great Outdoors Publishing Co., 1971.

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Schneider, Earl and L.F. Whitney. **The Complete Guide To Tropical Fish**. New York, N.Y.: Nelson, 1957.

Oyster Power

Level: 6-8

Pre-Lab

Concept

- Oyster adaptability

Facts

- The common eastern oyster, **Crassostrea virginica,** is a bivalve.
- The bivalve is a two-shelled animal.
- The oyster has two shells: a heavy cupped left shell and a flat right shell.
- Oysters are permanently attached to hard substrates below the average tide level.
- The two shells are held together by an elastic ligament known as the hinge.
- The left shell grows faster than the right and keeps the oyster from being smothered on muddy bottoms.
- The opposite end of the hinge is the bill.
- The oyster feeds by causing water to flow into one side of the bill and out the other.
- The water flow is caused by the beating of the cilia on the gills.
- Food is filtered out of the water by the gills using mucus nets.
- The inside shell contains a scar of the adductor muscle.
- The flow of the water may be demonstrated by the use of India ink or diluted food coloring.
- The feeding process may be demonstrated by the use of Carmine powder or lab grade powdered charcoal.
- Oysters are eaten and enjoyed by many people.

Suggested Prerequisite Skills

- The student should be able to use the compound microscope.
- The student should be able to make a wet mount slide.

Student Performance Objectives

- Given an oyster, the student will be able to identify the right and the left shells.
- Given a live oyster and food coloring, the student will be able to observe the water flow through the oyster.
- Given a piece of gill from an oyster, the student will observe the beating cilia.

Materials, Times, Cautions

Materials

- A live oyster
- An oyster shell
- Compound microscope
- Slide
- Cover slip
- Food coloring or India ink
- Scissors

Time

This lab can be completed in one period of 55 minutes or could be extended for two class periods.

Cautions

- The students should be cautioned not to tap or agitate the feeding oyster before beginning the feeding step of this activity.
- Never keep **Thais** snails in an aquarium with oysters.
- Adding a number of live brine shrimp to the bowl of seawater may induce the oysters to feed.

Suggestion

- Solutions of Carmine or charcoal may be made by stirring a small amount of the powder with seawater.

Definitions of Terms

Adductor muscle	Two types of muscle tissue make up the adductor muscle which closes the two shells when the oyster is disturbed.
Beak	The narrow end of the oyster where the hinge is located.
Bill	The broad end of the oyster. The end where the water enters and leaves during feeding.
Bivalve	Two-shelled animals such as oysters, clams and scallops.
Cilia	Minute hairlike structures which are capable of movement. In the oyster, they are found on the gills and cause the water to flow through the oyster.
Gonad	The male or female reproductive glands in the oyster. The oyster begins as a male, then changes to a female. This is possible since primary cells, which form eggs and sperm, are located in the gonad. It is impossible to tell the sex of an oyster except when it is producing sperm or eggs.
Hinge	The hinge is composed of the ligament which opens the oyster when the adductor muscle is relaxed.

Mantle	The outer layer of the oyster tissue which secretes the shell, adding more shell at the edge as it grows.
Shuck	(to shuck oysters) a special knife is inserted between the shells which severs the adductor muscle, allowing the top shell to be removed or the whole oyster to be removed from both shells.
Substrate	The substance to which an organism is attached or on which it lies.
Visceral mass	The large mass of tissue near the bill of the oyster which contains the digestive glands, gonads, stomach and a portion of the intestine.

Oyster Power
Student Lab

General Information

The oyster and clams are called bivalves. This means that they have two shells hinged on one side. Oysters live attached to any hard substrate below the mean tide level. They feed on small bits of organic matter and microscopic animals and plants that they filter from the water. People enjoy eating oysters.

Objectives

- To observe the make-up of an oyster shell and a living oyster.
- To observe the water current that flows through the oyster.
- To observe how the oyster traps its food.
- To observe the beating cilia in a small piece of gill tissue from an oyster.

Materials

- Microscope
- Slide
- Cover slip
- Forceps
- Scissors
- Medicine dropper
- Living oyster shell
- Colored fluid (India ink or diluted food coloring)
- Dilute HCl

Processes	Student Discovery Activity
	Part I External Anatomy
	1. Place a live oyster on the desk in front of you.
Observing	2. How are the shells different?
Inferring	3. Why are they different?
Observing	4. Notice the broad end of the oyster. This is called the **bill.**
Observing	5. Notice the opposite end, it is pointed and called the **beak.**
	6. On the beak is the **hinge.** The hinge is made up of a rubberband ligament that pulls the two shells apart.
Inferring	7. Why is the oyster closed?
Observing	8. Look at the inside of a single oyster shell. What do you see?
	9. The large purple spot near the bill end is the scar of the **adductor muscle.** When the oyster feeds this muscle closes the shell and opens it.
	10. Most clams have two adductor muscles, but the oyster only had **one.**
Predicting	11. What do you think the shell is made up of?
	12. Break off a small piece and place it on your table.
Predicting	13. What will happen to the shell if dilute HCl is dropped on it?

14. If the shell bubbles, calcium is present.

Inferring 15. Where do you think calcium comes from to make the oyster shell?

Communicating 16. Make a drawing of an oyster shell. Label the following:

left or right shell
beak
bill
adductor muscle scar

Part II The Feeding Oyster

1. Observe an oyster feeding. The two shells should have a gap at the bill end.
2. Carefully put a drop of colored fluid or carmine solution on one side of the bill.

Observing 3. What happened?

4. Place a drop of solution on the other side of the bill.

Observing 5. What happened?

Part III The Opened Oyster

1. Observe an oyster which your teacher has recently opened or shucked. If you were in a restaurant, this would be "Oyster on the halfshell."

Observing 2. Which shell is the serving bowl?

3. The outer layer of tissue is called the mantle. The **mantle** secretes substances into the shell for its growth.

Observing 4. The **adductor muscle** is in the center of the bill end. It is made up of two types of muscle. The small white portion keeps the shell closed for long periods of time. The larger, clearer portion swiftly closes the shell when the oyster is disturbed.

Observing 5. The area toward the beak is called the **visceral mass.** It is made up of the digestive system and the gonads.

Observing 6. Lift up the mantle and expose the feathery gills.

Communicating 7. Count and record the number of gills you observe.

Predicting 8. How do you think cilia (tiny hair-like projections) in the gill move?

9. Clip off a very small piece of a gill and place it on a microscope slide.

Observing 10. Place a drop of seawater on the gill and cover it with a cover slip. Look at the piece of gill under **low** power and focus.

Observing 11. Center the beating cilia under the **high** power objective.

Observing 12. How does the cilia move?

Inferring 13. How important for survival is this cilia movement?

Communicating 14. Draw the internal anatomy of the oyster. Use all the underlined words to label your drawing.

Definition of Terms

Adductor muscle Two types of muscle tissue make up the adductor muscle which closes the two shells when the oyster is disturbed.

Beak The narrow end of the oyster where the hinge is located.

Bill The broad end of the oyster. The end where the water enters and leaves during feeding.

Bivalve	Two-shelled animals such as oysters, clams and scallops.
Cilia	Minute hairlike structures which are capable of movement. In the oyster, they are found on the gills and cause the water to flow through the oyster.
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Shuck	(to shuck oysters) a special knife is inserted between the shells which severs the adductor muscle, allowing the top shell to be removed or the whole oyster to be removed from both shells.
Substrate	The substance to which an organism is attached or on which it lies.
Visceral mass	The large mass of tissue near the bill of the oyster which contains the digestive glands, gonads, stomach and a portion of the intestine.

Oyster Power
Post-Lab

Possible Answers to Questions

Part I. External Anatomy

2. The right shell is flat and the left shell is cupped.
3. The left shell (cupped grows faster than the flatten right shell). This behavior allows the oyster to keep the lip of its shell above the mud bottom.
7. There is something inside the shell that keeps it closed.
8. Students should see a large purple spot.
11. Answer will vary. However, it is white or chalky in appearance.
13. Answer will vary. However, if the shell bubbles, then the shell is made of calcium.
15. Answer will vary. However, calcium is found in the seawater.

Part II. The Feeding Oyster

3. Answer will vary.
5. Answer will vary.

Part III. The Opened Oyster

2. The left cupped shell.
7. Two or four gills.
8. Answer will vary.
12. Cilia moves in **one** direction.
13. The cilia moves the water over the gills so that the oyster can breathe and feed. It is, therefore, extremely important for survival.

Discussion

Oysters are a well known but little understood animal in our society. Beloved by the connoisseur, oysters are often feared by the young and uninitiated. As experimental animals, oysters are very cooperative. They do not walk away when you put them down. You can carry them around all day in a dry bucket without fear of killing them. They are temperamental feeders sometimes. Add live brine shrimp larvae to the seawater and leave them undisturbed for awhile. They should commence feeding in a short time.

Evaluation

The students should be able to meet all the objectives. The only part which might present a little difficulty, depending on the time you have and the temperament of the oyster, is the oyster feeding phase, Part II.

Follow-Up

- An activity using powdered charcoal would be very interesting. Place a small amount of this substance (obtainable from Ward's or other supply houses) in the water and observe the length of time it takes a feeding oyster to clear the water. Later observe the bottom of the bowl for pseudofeces - the rejected particles of inedible food.
- A similar activity might be done with Carmine powder.
- A subsequent activity could be to open the shells and observe the Carmine powder on the gills.

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Light and Gravity and the Rock Louse

Level: 6-8

Pre-Lab

Concepts

- Light affects the rock louse.
- Gravity affects the rock louse.

Facts

- Rock lice can also be called pillbugs, sowbugs, or isopods.
- Rock lice are crustaceans.
- They have two pairs of antennae.
- Rock lice feed on microscopic plants and animals.
- Rock lice are mostly scavengers.
- Many species of rock lice are parasitic.
- Rock lice **(Ligia)** live in and around wharfs.

Suggested Prerequisite Skills

- Student must be able to report visual observations into written form.

Student Performance Objectives

- Given an experimental chamber for rock lice **(Ligia)**, set up an experiment to determine their response to light.
- Given an experimental chamber for rock lice **(Ligia)**, set up an experiment to determine their response to gravity.

Materials, Time, Cautions

Materials

- Live rock lice **(Ligia)**
- Clear plastic box with lid (shoebox size)
- Paper towels and toilet paper
- Black constuction paper
- Clock with second hand
- Scissors
- Masking or clear tape
- Lamp
- Cardboard
- Metric ruler
- Saltwater

Time

This activity will take one or two class periods.

Cautions

- Do not place the lamp too close to the lid of the plastic shoebox.
- In both parts of the investigation, a saltwater dampened paper towel or saltwater dampened toilet paper should cover the bottom of the shoebox.

Definition of Terms

Innate behavior	Unlearned behavior.
Modified behavior	Learned behavior.
Taxis	A response to a stimulus.
Positive taxis	A movement toward a stimulus.
Negative taxis	A movement away from a stimulus.

Light and Gravity and the Rock Louse
Student Lab

General Information

Rock lice are an example of an organism that responds to changes in its environment. Biologists refer to these responses as behavior. Behavior may be of two types: unlearned or learned. The movement of animals in response to a stimulus is called taxis. If the animal moves toward the stimulus it is termed a positive response. If the animal, however, moves away from the stimulus, it is called a negative response. Responses to different stimuli are named according to the stimulus: Phototaxis (light), Geotaxis (gravity), Hydrotaxis (water), and Thermotaxis (heat).

Objectives

- To conduct experiments which will reveal the rock lice's unlearned response to light and gravity.
- To observe and record data on the behavior of **Ligia.**
- To design new experiments to test rock lice's behavior to light, gravity, water or temperature.

Materials

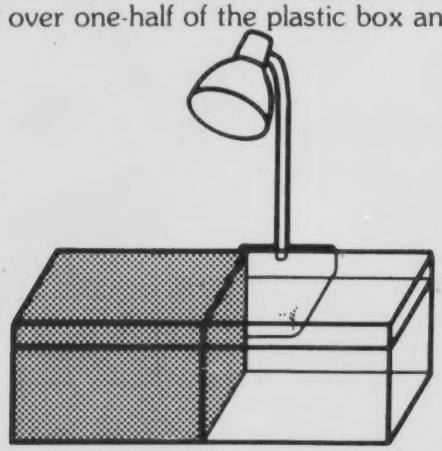
- Live rock lice **(Ligia)**
- Clear plastic box with lid (shoebox size)
- Paper towels and toilet paper
- Black construction paper
- Scissors
- Tape
- Lamp
- Cardboard
- Metric ruler
- Clock with second hand
- Saltwater
- Toilet paper

Processes

Student Discovery Activity

Part A. Response to Light (Phototaxis)

1. Prepare an experimental chamber for the rock lice by taping black construction paper over one-half of the plastic box and one-half of the lid.



2. Position a lamp above the chamber so that the light shines directly on it.
3. Place a paper towel soaked in saltwater in the bottom of box.
4. Place six rock lice inside the chamber.
5. Wait five minutes.

Observing Communicating

6. Observe and record in Table 1 the number of **Ligia** in the exposed area and the number under the black construction paper area.

Table 1 - Response to Light: Individual Data

Trial	Light	Dark
1	_____	_____
2	_____	_____
3	_____	_____
4	_____	_____
5	_____	_____
Individual Totals		

Observing Communicating

7. Repeat this procedure for four more trials. Record your observations for each trial.

Collecting data Communicating

8. Total all data from each column. Record this number under "individual totals" in Table 1.

Communicating

9. Record class totals in Table 2.

Table 2 - Response to Light: Class Data

Trial	Light	Dark
1	_____	_____
2	_____	_____
3	_____	_____
4	_____	_____
5	_____	_____
Class Totals		

Interpreting data

10. Based on class totals, what was the general response of **Ligia** to light? (Hint: positive/negative _____ taxic).

Inferring

11. Does **Ligia's** response to light have any adaptive or protective value? Explain.

Predicting

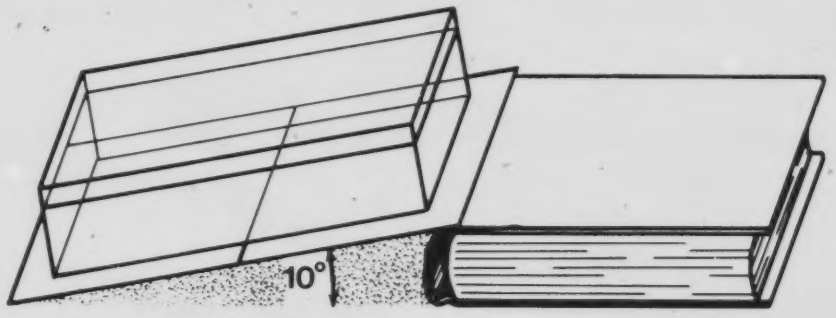
12. If you were redesigning the investigation, how might you show that rock lice are sensitive to natural light rather than light from a lamp.

Predicting 13. How might you show that **Ligia's** behavior is or is not being influenced by heat from the lamp rather than light from the lamp?

Experimenting 14. Using your own paper, design an experiment testing to see if only special areas on the animal are sensitive to light.

Part B. Response to Gravity (Geotaxis)

1. Cut a piece of cardboard slightly larger than the plastic box.
2. Draw a straight line across the middle of your cardboard.
3. Tilt your cardboard at an angle of about 10° with the table top. Support the cardboard with a book.
4. Place the clear plastic box (black construction paper removed) on the cardboard. Make sure damp pieces of toilet paper cover the bottom of the box.



5. Wait one minute. Record the number of **Ligia** above and below the line in Table 3.

Table 3. Response to Gravity: Individual Data

Trial	Positive	Negative
1	_____	_____
2	_____	_____
3	_____	_____
4	_____	_____
5	_____	_____
Individual Totals		

Observing 6. Repeat the entire procedure four more times. Remember to set the box on a flat surface and allow the **Ligia** to move about freely between trials.

Communicating Collecting data 7. Record all results in Table 3. Total data for each column and record this number under individual totals in Table 3.

Table 4. Response to Gravity: Class Data

Trial	Positive	Negative
1	_____	_____
2	_____	_____
3	_____	_____
4	_____	_____
5	_____	_____
Class Totals		

Communicating 8. Record class totals in Table 4.

Interpreting data 9. Based on class totals, what was the general response of **Ligia** to gravity?

Predicting 10. Can you improve on the experimental design for Part B?

Inferring 11. Explain why experiments on animal behavior may be difficult to conduct and interpret.

12. Return the rock lice to their normal habitat in the laboratory and clean up all equipment you used.

Light and Gravity and the Rock Louse
Post-Lab

Possible Answers to Questions

Part A

10. Negative phototaxic.
11. **Ligia's** response to light is adaptive.
12. Answer will vary.
13. Answer will vary.
14. Responses will vary with individual students.

Part B

9. Negative geotaxic.
10. Answer will vary.
11. Answers should include the control of variables, etc.

Discussion

Behavior of the rock lice should show a negative response to both light and gravity. The adaptiveness of the rock lice to their environment is very similar to those of amphipods. Two natural phenomena such as stormy seas and extended heavy rain induce massive landward migrations of **Ligia**.

Evaluation

- Students should do well in this activity. All concepts should be mastered.

Follow-Up

- The influence of maturational and experiential factors on direction preference is not known; these and other factors could be investigated.

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How Old Am I?

Level: 6-8

Pre-Lab

Concept

- Scales

Facts

- Most fish have scales which protect them.
- As fish grow older, the scales get larger and produce growth rings (circuli) similar to trees.
- An annulus is a darker ring of circuli which forms where the circuli are spaced close together.
- The age of a fish can be determined by counting the number of annuli on its scales.

Suggested Prerequisite Skill

- Be able to use a microscope.

Student Performance Objective

- Given a fish scale, the student will count the number of annuli to determine the age of the fish.

Materials, Time, Caution

Materials

- Fish scale from under the pectoral fin
- Microscope
- Forceps
- Clean microscope slides
- Silicon glue

Time

One class period of 30 minutes is needed for this activity.

Caution

None.

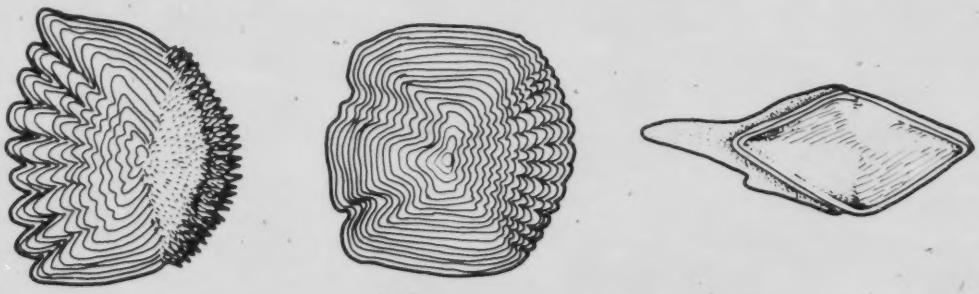
How Old Am I?
Student Lab

General Information

Most fish have scales. Some, like the catfish, have no scales and are said to be "naked." Fish such as the trout and freshwater eels have scales that are very small.

Scales are used for protection, much like our fingernails. Rather than protecting just a small part of the body, though, scales protect most of the body of the fish from sharp objects which might pierce or cut their skin. Scales give the fish coloration because they have color pigments in them. Fish have a lateral line which enables them to detect wave vibrations in the water. The scales along the side which make up the lateral line contain sensory receptors.

Bony fish have three types of scales. A ctenoid (teen-oid) scale has small spines on one end. A cycloid (cyc-loid) scale is a smooth scale. A ganoid scale is a thick plate-like scale found on sturgeons and gars.



Small scales cover the body of a newly hatched fish. The center (focus) of an older fish's scale represents the scale when the fish was newly hatched. The scales get larger as the fish grows. As the scales grow, they produce small circular growth rings (called circuli) around themselves. A fish grows faster in the summer and slower during the winter. During the summer the circuli are widely spaced; however, in the winter, the circuli are spaced very close together. A dark ring is formed where the circuli are spaced close together. The darker ring of circuli is called the annulus. The age of a fish can be determined by counting the number of annuli on its scales.

Objective

- To determine the age of a fish by counting the number of annuli on its scales.

Materials

- Microscope
- Forceps
- Silicon glue
- Fish scales (at least three) from under the pectoral fin
- Clean microscope slides

Processes	Student Discovery Activity
	1. Put one small drop of silicon glue at each of the four corners of a clean microscope slide.
	2. Place one, two or all three scales on the slide (if there is room). Allow room for the spreading glue when the second slide is placed on top.
	3. If the scales are large, three individual slide preparations will have to be made.
	4. Place a second microscope slide on top of the first and press firmly.
	5. Place a book or a weight on top of the slides and allow at least one hour for the glue to dry.
Observing	6. Observe the scales under a microscope.
Communicating	7. Make a drawing of the three scales: Focus, Annuli and Circuli. If they are ctenoid scales, indicate the cetnii (small spines).
Observing	8. How old is the scale?

How Old Am I?
Post-Lab

Possible Answer to Questions

8. Answer will vary.

Discussion

The best place to take scales, for age determination, is from under the fish's pectoral fin. Why? The pectoral fin has a tendency to protect scales and keep them from being lost. Newer scales will have fewer annuli than an original scale.

How could age determination of fishes be useful in fishery biology?

Evaluation

- What is the primary function of scales?
- On which part of the fish's body would you most likely find original scales?
- Draw and label a five-year-old scale.

Follow-Up

- Repeat the activity with the ctenoid and ganoid type scales.
- Get scale samples from fish at the market and determine the average age for marketable fish of different species.

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The Culturing of Brine Shrimp Larvae

Level: 6-8

Pre-Lab

Concept

- Brine shrimp culturing.

Suggested Prerequisite Skill

- Student must be able to follow directions.

Student Performance Objectives

- The student will culture brine shrimp larvae.
- The student will learn how to maintain brine shrimp life processes.

Materials, Time, Caution

Materials

- Shallow plastic or porcelain pan
- Plastic divider, cut to include arms that suspend 2mm off the bottom of the pan
- Incadescent light source
- Synthetic or commercial seawater mix
- Brine shrimp eggs (**Artemia**)
- Triple-beam balance
- Small mesh brine shrimp net
- Air pump, tubing and air stones
- Pipette
- Glass tubes
- Eye droppers

Time

The activity is designed to last as long as brine shrimp are needed for food.

Cautions

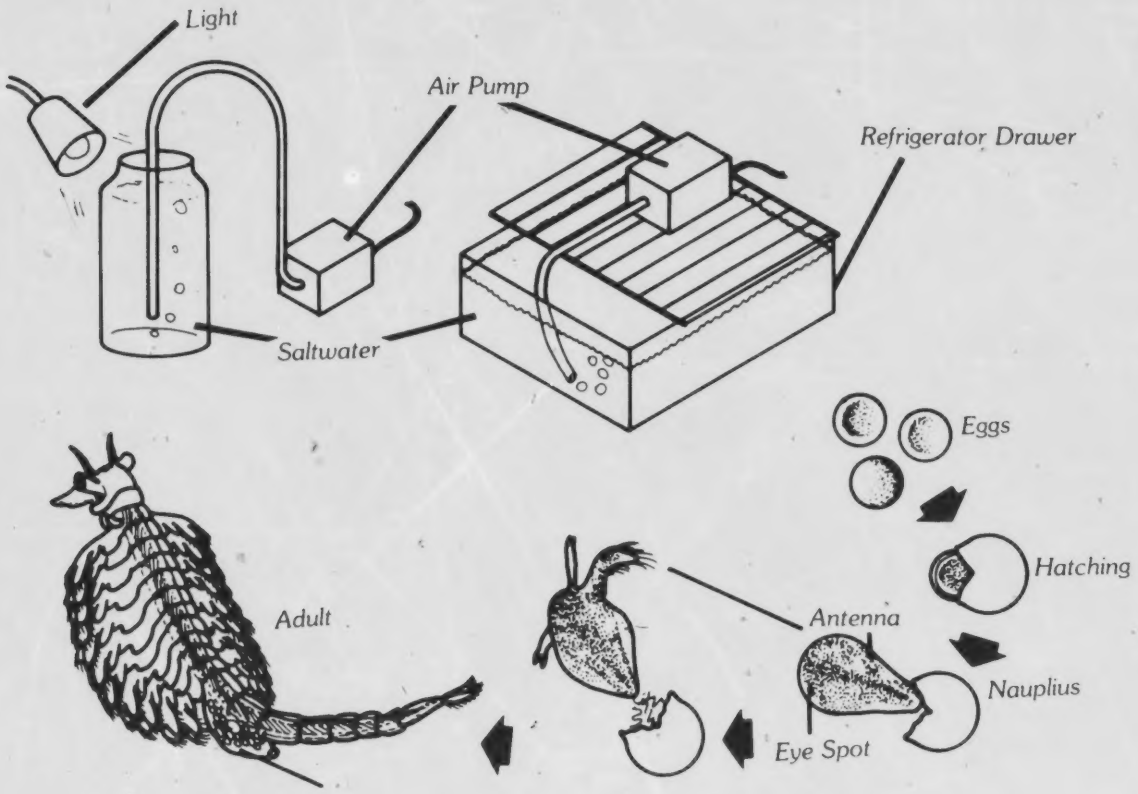
The shrimp eggs and dog food vitamins are available at a pet store; dried yeast, at a grocery store; sea salt, at drug store; epsom salt and non-iodized salt from a grocery store. Always use non-iodized salt. Care is needed to avoid contamination by dip net. Pipettes, glass tubes or eyedroppers are recommended.

The Culturing of Brine Shrimp Larvae
Student Lab

General Information

Baby brine shrimp are too small for many animals. Larger fishes, for example, require larger forms of live food. For them adult brine shrimp are ideal, since they grow to 50 millimeters in length. An adult brine shrimp culture is simple to maintain once it has been started. Left over newly hatched shrimp can be added periodically. Often the adult shrimp will mate and reproduce, thereby helping to sustain the culture.

Once they become adults, brine shrimp can be kept alive if refrigerated. Pour them in a plastic or porcelain shallow baking pan and set the pan on a shelf in the refrigerator or use the vegetable crisper as a holding tray. Put an airstone in the water. The source of air can be an inexpensive vibrator compressor that is also kept in the refrigerator. Run the cord from the compressor between the molding of the refrigerator door and plug it into a nearby wall outlet. Keep the temperature inside the refrigerator about 10°C.



Objectives

- To culture brine shrimp larvae.
- To learn how to maintain brine shrimp life processes in a laboratory.

Materials

- Shallow plastic or porcelain pan
- Plastic divider, cut to include arms that suspend 2mm off the bottom of the pan.
- Incandescent light source
- Synthetic or commercial seawater mix
- Brine shrimp eggs (**Artemia**)
- Triple-beam balance
- Small mesh brine shrimp net
- Air pump, tubing and air stones
- Pipettes
- Glass tubes
- Eye droppers

Processes **Student Discovery Activity**

1. Follow the steps listed below.
2. Be careful that you do not let the shrimp net dry with the salt solution on it.
3. Always rinse the net after using and let dry or the hypersalt will kill the young as you catch them.
4. The light that is used to attract the shrimp should not be left on more than 30 minutes or it will heat the water, driving out the oxygen.
5. Dip net or pipette used in the oil topped solution should be used only in that jar and **no other** or the oil film will spread to other jars.

Part I. How to Hatch Brine Shrimp: Moderate Amount

Measuring 1. Fill a clean 1 liter jug 3/4 full of tap water aged three days at 21-27°C.

Measuring 2. Add 6 level tablespoons (360 g per liter) of table salt (NaCl) through a funnel. Stir.

Measuring 3. Add 1 level teaspoon of brine shrimp eggs through the funnel. (The eggs can be purchased at aquarium supply stores.)

Observing 4. Drop in an airstone and aerate the water vigorously until eggs hatch (1 or 2 days).

5. After hatching, remove the airstone and let empty shells settle to the bottom of the jug.
6. Brine shrimp are strongly attracted to light, so it is easy to concentrate them in one area before trying to remove them. This can be done by shining a light at one side of the jug near the top.
7. When most of the shrimp are concentrated under the light, siphon them into another container through the length of tubing, pipette, eyedropper or glass tube.
8. Dump out the water and eggshells, rinse out the jug under the tap, and start another culture. When two jugs are kept going, one of them can be emptied.

Part II. How to Raise Brine Shrimp: Large Amount

1. Hatch 3 flat tablespoons of brine shrimp eggs by the method just described.

Measuring 2. Dissolve 600g of table salt (NaCl) in about 37 liters of tap water in a plastic garbage can. When the salt has completely dissolved, adjust the specific gravity to 1.025.

Measuring 3. Add 60g of epsom salt ($MgSO_4$).

4. Drop an airstone in the can and aerate the water vigorously for two days.

Observing 5. Add the larval shrimp.

Measuring 6. Add 30g of dog vitamin premix (sold by the pound at most pet stores) to the can each day.

7. The shrimp grow to adulthood in about three weeks if temperature is 21°-27°C. Remove them as needed with a net.

Part III. How to Raise Brine Shrimp: Small Amount

Measuring 1. Prepare a solution of 36g of synthetic salts or commercial salt (non-iodized) to a liter of aged tap water. Place the solution in a shallow pan.

Measuring 2. Add brine shrimp eggs.

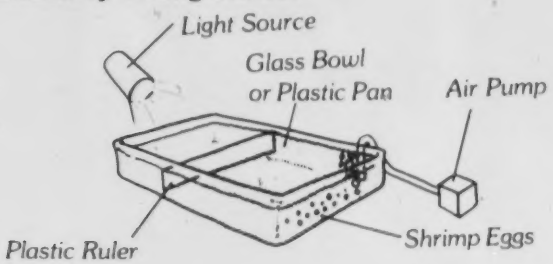
3. Place divider 1/4 the distance from one end and cover the remaining 3/4 of the pan with aluminum foil. Confine the eggs to the covered side of the pan.

4. Set up a light source at the open end of the pan and leave the culture at room temperature.

5. Turn on the light to increase the hatching speed by raising the temperature. This will attract freshly hatched baby brine shrimp to the open area of the pan, where they can be netted easily. The divider prevents the eggs from rolling to the lighted area. Baby brine shrimp should continue to hatch for four to five days.

6. Set up an identical tray and alternate, introducing brine shrimp into solution every two or three days for continuous supplies of fresh food.

7. Rinse the collected brine shrimp while they are still in the net since increased salinity and possible contamination may result if placed directly in the aquarium surrounded by strong brines.



Part IV. Questions and Observations

Inferring 1. Why do you think salt is necessary for the shrimp to survive?

Observing 2. What do you think is the purpose of the airstone or bubbling air tube?

Inferring 3. The brine shrimp is an active animal. Will the shrimp require more or less oxygen than an inactive animal?

Inferring 4. What biological response enabled you to collect brine shrimp?

Applying 5. If "photo" means light and "tropic" attracted, what word would describe this behavior?

The Culturing of Brine Shrimp Larvae
Post-Lab

Possible Answers to Questions

1. Answers will vary.
2. To add oxygen to the water.
3. More oxygen.
4. Phototropic response.
5. Phototropic.

Discussion

"Artemia is frequently cited in biology classes as an animal which in different environments varies so greatly in appearance as to seem to be two different species.

"If Brine Shrimp are hatched in water with but a small amount of salt and several generations are raised, the Brine Shrimp appears one way. If, however, the generations are raised in increasingly salty water, the Brine Shrimp looks like another species. Brine Shrimp from Great Salt Lake in Utah appear different from Brine Shrimp found in the ocean off the Connecticut shore: The species changes to suit its environment." (Schneider and Whitney).

The above discussion should be available to all students. Elementary students should be given a version they comprehend.

Evaluation

- Allow time to observe and record the information on the brine shrimp.
- Have groups discuss and compare their results.
- Discuss the differences that occur, even though students followed the same procedure.

Follow-Up

- The Baby Shrimp Nursery activity.
- The Salt Factor In Raising Brine Shrimp Activity.
- The Effects of Light, Oxygen and Temperature on the Hatching of Brine Shrimp activity.

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Shiotz, Arne. **A Guide To Aquarium Fishes and Plants.** Philadelphia, Pennsylvania: J.B. Lippincott, 1971.

Schneider, Earl and L.F. Whitney, **The Complete Guide To Tropical Fish.** New York, New York: T. Nelson Co., 1967.

Are Seafoods Good for Us?

Level: 6-8

Pre-Lab

Concept

- Foods contain different chemical groups.

Facts

- Sugars and starches are members of the chemical group call saccharides.
- Fats and proteins are chemical groups also found in foods.
- Seafoods contain various elements of the basic food groups, and thus are foods useful to man.

Suggested Prerequisite Skills

- Student must be able to measure liquid quantities.
- Student must be able to make visual color discriminations in liquids.
- Student must be able to handle caustic chemicals carefully.

Student Performance Objectives

- Given known seafoods, the student will identify the specific food groups they contain by chemical tests.
- Using various confirmation tests, the student will discriminate sugars, starches, fats and proteins.
- Given the basic equipment, the student will assemble and use a hot water bath in performing tests.

Materials, Time, Cautions

Materials

- 250ml beaker
- 3 small test tubes
- Monosaccharide (sugar)
- Disaccharide (sugar)
- Polysaccharide (starch)
- Cooking oil
- Heat source
- Benedict's solution
- Stirring rod
- IKI solution
- Seafood sources (shrimp, mussel, oyster, fish meat or other sources)
- Brown paper towel
- Unflavored gelatin
- Nitric acid
- Eye dropper

Time

Plan to allow more than one class period for this activity.

Cautions

- You will need some concentrated nitric acid for protein tests. Small reagent bottles will do, with two bottles for the entire class.
- Inform students of the hazard involved in using nitric acid, and that it should not be brought into contact with the skin. Flush with water if this happens.
- Small 8cm test tubes will work well for this activity.
- You will need two small bottles of Benedict's solution for the sugar tests. Prepare in advance.
- Two small bottles of IKI solution will be needed. (Prepare by dissolving 1.5g of iodine and 5g of potassium iodide in 500ml of water. Keep contents stored in dark bottle and/or dark place.)
- Prepare a monosaccharide solution by dissolving 10g of table sugar (sucrose) in 100ml of water and store.
- The polysaccharide solution can be made by dissolving 10g of starch in 100ml of water. Stir thoroughly before use for each test.
- You might want to substitute different forms of seafoods than those mentioned.

Are Seafoods Good for Us?
Student Lab

General Information

Nutrition is an essential process to all living things. The foods consumed by organisms provide the large group of chemical compounds found in the cells of living animals. The compounds are used for many purposes including energy and structure. Carbohydrates are used for energy in the cells. Fats become a part of all cellular membranes and they can also serve as an energy source. A third group of compounds, proteins, play an important role in forming internal structures of cells.

The sea produces a wide variety of foods which are consumed by ocean inhabitants as well as man. Thus, the needs of nutrition may begin to be satisfied. Foods from the sea do much toward meeting this goal.

Objectives

- To determine the presence of carbohydrates in foods for the sea.
- To determine the presence of fats and proteins in known foods as well as foods from the sea.

Materials

- 250ml beaker
- 3 small test tubes
- Monosaccharide (sugar)
- Disaccharide (sugar)
- Polysaccharide (starch)
- Cooking oil
- Heat source
- Benedict's solution
- Stirring rod
- IKI solution
- Seafood sources (shrimp, mussel, oyster, fish meat or other sources)
- Brown paper towel
- Unflavored gelatin
- Nitric acid
- Eye dropper

Processes

Student Discovery Activity

Look for Carbohydrates

1. Fill a 250ml beaker one-half full with tapwater and place on a hot plate, bringing the water almost to a boil.
2. Number 3 small test tubes 1, 2, 3. In tube 1, place 40 drops of monosaccharide

sugar; in tube 2 place 40 drops of disaccharide sugar; in tube 3 place 40 drops of polysaccharide starch.

3. Add 40 drops of Benedict's solution to each of the 3 test tubes.

Observing 4. What is the color of Benedict's solution?

5. Place the 3 test tubes into the hot water and leave for about 4 minutes.

6. Remove tubes and observe each for color. (If certain saccharides are present the original color will change to green, yellow, orange or red. In this case the result of this test is positive (+).

Communicating 7. Record your results in the table below:

Table 1: Sugars and Starches

Test Tube	Test Subject	Test Results (record + or -)
1	Monosaccharide	Benedicts: IKI:
2	Disaccharide	Benedicts: IKI:
3	Polysaccharide	Benedicts: IKI:
4	Shrimp meat	Benedicts: IKI:
5	Fish meat	Benedicts: IKI:
6	Mussel meat	Benedicts: IKI:

Measuring 8. In 3 clean test tubes numbered 1, 2, 3, place 2ml (40 drops) of each of the original test liquids from step 2 above.

Measuring 9. To each tube add 2 drops of IKI solution, then mix contents by swirling tube. (Polysaccharides present will be indicated by a black or blue-black color when IKI is added. In this case your test is positive).

Communicating 10. Record your observations in Table 1 above.

Observing 11. How many of the test subjects showed starch?

12. In a clean test tube marked number 4, place a small piece of crushed shrimp meat; to a tube marked 5, add a small piece of fish meat; to a tube marked 6, add a small piece of mussel meat.

13. Add 2ml of tap water to each tube.

14. Using a glass rod, stir contents of each tube to form a ground liquid puree.

Measuring 15. Add 40 drops of Benedict's solution to each tube and place them in the beaker of hot water for 4 minutes.

Communicating 16. Remove each tube and observe color change.

Observing 17. Did the seafoods reveal that sugars were present?

18. In clean test tubes marked 4, 5, and 6, place the same amount of seafood substances as in step 12 above. Add water and grind up each substance.

Measuring 19. To each tube add 4 drops of IKI solution. Swirl contents of each tube thoroughly.

Communicating 20. Look at each test tube and record your results for the polysaccharide test in Table 1.

Inferring 21. From what you observed in the three tests, do you feel seafoods are rich sources of starches?

Look for Fats and Proteins

22. On a piece of brown paper towel, place a drop of oil and allow it to stand for 15 minutes.

23. On the same paper, place a drop of water in another area.

Predicting 24. Which of these two drops do you think will disappear from the paper first?

Observing 25. After 15 minutes, examine the paper to see if the spots dried by holding paper up to a light. (If the spots appear to remain wet the original substance is a fat.)

Communicating 26. Record your results in Table 2 below either positive (+) or negative (—) for fats.

Table 2: Fats and Proteins

Test Tube	Test Subject	Test Results	
		Fat	Protein
1	Oil		
2	Water		
3	Shrimp		
4	Fish		
5	Mussel		

27. Repeat step 22 above using a piece of shrimp meat, fish and mussel meat. Rub the meat into the towel, remove and let wet spot dry as before.

Observing 28. Examine the spots and record your results in Table 2.

Inferring 29. Do the seafoods tested show that some fats are present?

30. In three clean test tubes, place a small piece of shrimp in one, fish in the second, and mussel in the third.

Measuring 31. To each test tube add about 20 drops of nitric acid. (If substance being tested contains protein it will turn yellow).

32. After a couple of minutes, observe each test tube and record your results in Table 2.

Inferring 33. From what you observed in this test, can you say that seafoods contain protein?

Inferring 34. Go back and review the results of the tests on seafoods in Table 1 and 2. Based on what you found out, what can you say about the chemical nutritient makeup of the seafoods you tested?

35. Properly dispose of all wastes and clean up all equipment.

Are Seafoods Good for Us?
Post-Lab

Possible Answers to Questions

4. Benedict's solution is blue in color.
7. Results of Table 1: Sugars and Starches

Tube	Subject	Benedict's Test	IKI Test
1	Monosaccharide	+	—
2	Disaccharide	—	—
3	Polysaccharide	—	+
4	Shrimp		
5	Fish		
6	Mussel		

11. One showed starch.
17. Strong sugar results do not show. Sugars are absent.
21. Seafoods do appear to be rich sources of starches.
24. The water drop will disappear first.
26. Results of Table 2: Fats and Proteins

Tube	Subject	Benedict's Test	IKI Test
1	Oil	+	
2	Water	—	
3	Shrimp	—	+
4	Fish	—	+
5	Mussel	—	+

29. Answers may vary. As a rule, seafoods may be low in fat content and results will probably show negative, however some seafoods contain fats and may give a positive result.
33. Seafoods tested should be abundant in protein.
34. The nutritional makeup of these seafoods is such that they will show low sugars and fats and relatively high protein, making them good foods for man.

Discussion

Generally, this activity stimulates interest in the nutritional value of seafoods. Some students may have difficulty determining when the drops on the paper towel are really dry in the test for fats; comparison with fellow students should eliminate difficulties, however.

Evalution

You can expect good success with this activity and your students should gain a basic understanding of three nutritional food groups and their presence or absence in seafoods.

Follow-Up

- Other seafoods can be checked if they are available. Other more definitive tests of the food groups are available and can be applied.
- Have your students use reference books and list as many seafoods as they can, giving their nutritional values per portion.

A Field Trip Along the Beach

Level: 6-12

Pre-Lab

Concept

- Marine and estuarine life

Suggested Prerequisite Skills

Before this activity, the student should have a general understanding of the variety of animal life along the sea coast and the various niches which serve as habitats for these animals. Various reference books, with good illustrations, should be provided in advance. One method is to have students read the Golden Nature Book: The Sea Shore and answer about 20 questions.

Student Performance Objectives

- While visiting estuarine-marine environments, the student will observe and collect organisms from habitats within these environments.
- Given taxonomical characteristics, the student will develop skills in identifying specimens.
- Given feeding and locomotion characteristics of several estuarine and marine organisms, the student will be able to identify at least 10.

Materials, Times, Cautions

Materials

Collecting specimens:

- Tags and labels (ball point pen)
- Dixie cups with ice-pick punched holes
- Cottage cheese molds with holes punched in tops
- Plastic sandwich bags
- Dip nets
- Kitchen tongs
- Masking tape

Classifying organisms:

- Reference books (see Post-Lab)

Time

Try to arrange the schedule so you are collecting at low tide. Minimum time allowances are:

Pre-lab survey - 1 day
Onsite collecting - 1 day
Taxonomical classification - 2 days
Research on specimens - 2 days

Cautions

Many carnivores are cannibalistic. The blue crab, for example, will eat other blue crabs. Put only one animal in each container. Animals needing wet gills should have ample water in the bottom of the cottage cheese container. Watch out for poisonous animals, strong claws, sharp teeth, stings and other defensive weapons of marine-estuarine animal life. Empty shells can be collected by location in one container.

A Field Trip Along the Beach
Student Lab

General Information

Many times the beaches contain remnants of animals that have inhabited the various niches of the estuary and shore lines. These are usually shells. These shells frequently enclose or protect a very interesting animal. You should find some of these along niches in the Texas Gulf coast. The adaptations that have evolved over millions of years have enabled these animals to survive in some very challenging circumstances.

Students should be able to identify the animal by the specific characteristics of its shell. By researching these subjects briefly, you should be able to identify an animal's feeding habits or "methods of making a living" and other typical behavior patterns--how it uses its habitat to survive, its dependency on specific events in the habitats for survival (i.e., the oyster's dependency on a food carrying current as its food source). You will need to become familiar with these general feeding patterns:

1. Filter feeding is one of the most common and is usually done by straining microscopic plankton from the water. The filter feeder sometimes creates a current by moving its thousands of cilia. This current is driven through small holes (pores) lined with mucous coat bristles. At intervals, this plankton entangling mucous is sluffed off into the mouth. While there are variations in this process, clams, oysters, mussels, slipper limpets, sponges and some worms use this method. Barnacles use their long feathery legs for strainers while the sea anemone use tentacles with stinging cells to immobilize their food.
2. The sifter or deposit feeder is like the person harvesting potatoes; he sifts through the sediment for pieces of food. The animal's mouth parts are especially adapted to sift for food. While the worm will swallow copious amounts of sediments, its digestive tract chemically sorts the valuable parts. Some of these scavengers, like crabs, are predators that glean extra food from the bottom's smorgasbord.
3. As there are grazers (herbivores) on land, so there are grazers of the sea. The main source of food for these animals is algae. Limpets and littorine snails use a thin, flexible tooth-covered band to saw away the algal film. Sea urchins and crabs eat larger algae which they tear from the surface of jetties, rocks, etc.
4. Carnivorous animals obtain their prey by various methods, ranging from a concealed and camoflaged ambush to boring a hole through the shell of their prey with their toothed radula assisted by chemical secretions. Some crabs chip away shells with the lip of their own shell or pry open their prey's shell by sheer strength.

When you were born, you were put in a crib or a cradle (a small rocking bed). Today man believes that the first living things were born in the sea, that the vast rocking sea was the cradle of life. How do we know this? Because the ancient remains of these one-celled animals are found in rocks made from sediments on the ocean bottom. Animals caught in these sediments left imprints. When ocean bottoms are pushed up above the ocean, we can see these remains or imprints called fossils.

Life began in the ocean. Sea life moves by floating, swimming or creeping. While some animals, like the adult barnacle, anchor themselves and seldom move, others do. This movememt or locomotion is classified in the following ways:

1. Plankton means "wanderer." These animals drift with the current.
2. Nekton means "swimmer, good swimmer."

3. Benthos means "bottom mover." These animals crawl or creep about.
   Put the following animals into the plankton, nekton or benthos classifications:

_____ clams, oysters, starfish (crawlers or creepers)
_____ sharks, whales, red snapper (swimmers)
_____ diatoms, forams, jellyfish (floaters)
_____ crabs, lobsters, crayfish (crawlers or creepers)

The jungle forest in the ocean doesn't have trees growing in it, it has seaweed called sargassum. This sea jungle, called the Sargasso Sea, also has many sea animals and plants.

Not all animals get their oxygen from the water, Some, the mammals, breathe air as we do. They can drown if they are caught too long below the sea's surface. Some examples of sea mammals are porpoises and whales.

Objectives

- To observe and collect estuarine and marine organisms in their natural habitats.
- To become acquainted with the taxonomy of the organisms through observations and reading research.
- To learn and classify the locomotion and feeding habits of these animals.

Materials

- Tags and labels (ball point pen)
- Dixie cups with ice-pick punched holes
- Cottage cheese molds with holes punched in tops
- Plastic sandwich bags
- Dip nets
- Kitchen tongs
- Masking tape
- Reference books

Processes **Student Discovery Activity**

1. Collect observed specimen and put into a container. Complete tag and attach to the container. Place in shade. Do not put dissimilar animals together.

SAMPLE OF TAG

Location: Gilchrist Beach Dunes
Time: 8 a.m. p.m. Date: 6-10-80
Weather: Cloudy Overcast Temp: 21°C
Observations: Locomotion: Running in grassy dunes Food: Feeding on decaying shark
Name: Ghost Crab **(Ocypode quadrata)**

2. Through reading research, become acquainted with the taxonomy of the animals, their chosen habitats, their feeding habits, locomotion, reproduction and other pertinent characteristics of the organism.
3. Research one of the animal samples by filling in the following form: Use starred (*) items for younger grades; secondary students should complete both starred and unstarred.

Part I: Reading Research

A. Complete the classification of your specimen

Phylum:_____
Class:_____
Subclass:_____
Order:_____
Suborder:_____
*Family:_____
*Scientific Name:_____
(Genus) (Species)

B. Answer the following questions. State the source(s) of your reference(s).

Observing 1. What are the feeding habits of this animal?
Observing 2. What are the physical characteristics which separate this animal from the other animals of the same genus?
Hypothesizing 3. What species of this animal are found in the vicinity near your school?
Observing 4. What are the locomotion habits of this animal?
Inferring 5. Of what research interest is this animal to science?
Applying 6. Where is this animal in the food chain?
Inferring 7. How is this animal of economic importance to the U.S.? Other countries?
Hypothesizing 8. What other animals are in the same class as this animal?
Communicating 9. Draw this animal on a separate paper and label.

Part II: External Observation

Collect the following information about the animal you have found.

Collecting data 1. Length in centimeters.
Collecting data 2. Width in centimeters.
Collecting data 3. Mass in grams.
Communicating 4. Describe surface color of specimen's skin.
Applying 5. Classify animal by diet.
Observing 6. Open mouth, observe and describe teeth and jaw.
Observing 7. How does the animal move?
Observing 8. Identify the animal by its movement.

Part III: Internal Observation
(Optional)

Collect the following information about the animal you have found.

Communicating 1. Respiratory system (describe gills, number, pair).

Communicating 2. Circulatory system
Heart
Chambers (number)
Type of circulatory fluid

Communicating 3.

Digestive system	organs present	location
Gall bladder Pancreas Spleen Kidney Ovary Testes Rectal gland Other		

Communicating 4. Brain and Nervous System
The number of lobes
Spinal cord
Cranial nerves

Observing 5. Try to trace the optic nerve to the brain.

A Field Trip Along the Beach
Post-Lab

Possible Answers to Questions

- Answers will vary.

Discussion

- Students should share their reports with others through general oral report on their research in addition to a conducted discussion.

Evaluation

Students should record their summations on a chart similar to that below. The teacher should stress similarities and differences in the organisms and any unique characteristic.

Chart for Classification of Animals

Elementary Student

Common name of Organism (Scientific name of Organism)	Benthos (Bottom Crawler)	Nekton (Swimmer)	Plankton (Floater)	Feeding Method	Carnivorous	Herbivorous	Omivorous

Middle, Secondary Student

Common name of Organism (Scientific name of Organism)	Benthos	Nekton	Plankton	Feeding Method	Carnivorous	Herbivorous	Omivorous	Unique Characteristics

References

The following books are listed according to their importance as a reference for teachers of marine science. The most useful are listed first.

Fotheringham, Nick, and Bruenmeister, Susan Lee. **Common Marine Invertebrates of the Northwestern Gulf Coast**. Houston, Texas: Gulf Publishing Company, 1975.

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Cousteau, Jacques. **The Ocean World of Jacques Cousteau** (20 vols.). New York: Abrams, 1975.

The Sea: Ideas and Observations on Progress in the Studies of The Seas. 6 vols. New York: John S. Wiley, 1962--.

McCormick, Michael, editor. Ocean Engineering. (9 vols.). New York: John S. Wiley & Son, 1975--.

Several copies of each of the following books may be used as student references:

Abbott, R. Tucker. **Seashells of North America.** New York: Golden Press, 1968.

Crane, Jules M. **Introduction to Marine Biology, A. Lab Test.** Columbus, Ohio: Bell and Howell, Merrill, 1973.

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Miner, Roy Waldo. **A Field Book of Seashore Life.** New York: Putnam, 1950.

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Robbins, Chandler S.; Bunn, Bertel; and Zim, Herbert. **Birds of North America.** New York: Golden Press, 1966.

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Zim, Herbert S., and Ingle, Lester. **Seashores.** New York: Golden Press, 1955.

Zim, Herbert S., and Shoemaker, Hurst H. **Fishes.** New York: Golden Press, 1955.

The following Texas Parks and Wildlife bulletins may be used as student references or as short term texts:

Holfstetter, Robert P. **The Texas Oyster Fishery.** Bulletin No. 40, Austin: Texas Parks and Wildlife Department, 1959.

Leary, Sandra Pounds. **The Crabs of Texas.** Bulletin No. 43. Austin: Texas Parks and Wildlife Department, 1961.

Moffett, A.W. **The Shrimp Fishery in Texas.** Bulletin No. 50. Austin: Texas Parks and Wildlife Department, 1970.

Pew, Patricia. **Food and Game Fishes of the Texas Coast.** Bulletin No. 33. Austin: Texas Parks and Wildlife Department, 1954.

Simmons, Ernest G., And Brever, Joseph P. **The Texas Menhaden Fishery.** Bulletin No. 45A. Austin: Texas Parks and Wildlife Department, 1950.

Copies of the above bulletins may be obtained from Texas Parks and Wildlife Department, John H. Reagan State Office Building, Austin, Texas 78701.

Texts in Oceanography:

Anikouchine, et al. **The World Ocean: An Introduction to Oceanography,** 1973.

Davis, Richard A. **Principles of Oceanography.** Reading, Massachusetts: Addison-Wesley Publishing Company, 1972.

Weisberg, Joseph, and Parish, Howard. **Introductory Oceanography.** New York: McGraw-Hill Book Company, 1974.

Color Changes in Fish Scales

Level: 7-8

Pre-Lab

Concept

- Chromatophores are pigment cells found in many animals.

Facts

- The chromatophore is found in fish scales.
- It allows the fish to simulate various backgrounds.
- Numerous pigments make up chromatophores: Black, brown, blue, yellow, red and white.
- Chromatophores may be viewed in three stages of pigment spread: Concentrated, intermediate and dispersed.
- The mechanism by which the chromatophore functions is not fully understood but the pigments appear to flow through permanent channels in the cells.
- The chromatophores of fish are controlled by nerve impulses and hormones.
- Fish scales can easily be obtained from living fish.
- **Fundulus grandis,** the Gulf killifish (thought to be identical to the Atlantic mummichog), has chromatophores that contain melanin, a black pigment.
- KCl (potassium chloride) will concentrate the black pigment granules in **Fundulus** and NaCl (salt) will cause distribution of the pigment.

Suggested Prerequisite Skills

- The student should be able to make a wet mount slide.
- The student should be able to use a compound microscope.

Student Performance Objectives

- Given a fish scale, the student will observe a chromatophore to determine which state it is in.
- Given a fish scale, the student will draw several chromatophores.
- Given KCl or NaCl, the student will try to alter the state of the chromatophore.

Materials, Time, Cautions

Materials

- Compound microscope
- Microscope slide
- Cover slip
- Forceps
- Clothespins
- Living fish, such as the Gulf killifish, Fundulus grandis
- .1M or .2M KCl and NaCl
- Medicine dropper

Time

One class period of 55 minutes in length.

Cautions

When dipping out the fish, the student should be cautioned to leave the fish in the net and either hold it or place it on the table. Forceps should be used to return the fish quickly to the aquarium. Teachers may use a special technique to show chromatophores to students. Place several drops of silicone glue on a glass slide. Place two or three scales on the slide and cover with another slide. Clamp with two clothespins and allow to dry for one hour. Place the slides in a projector and focus on a screen. The chromatophores and their condition then can be indicated to the students.

Definition of Terms

Chromatophores	Pigment cells that allow animals to simulate varying backgrounds.
Melanin	Black and brown pigments.
Pigment	Coloring matter found in the cells or tissues of plants and animals.

Color Changes in Fish Scales
Student Lab

General Information

Chromatophores are pigment cells that are found in various animals including the scales of fish. The chromatophore allows the fish to change colors to blend in with its background. It also permits the fish to become brightly colored in order to attract a mate or to scare an enemy. Many pigments may be found in chromatophores, such as black, brown, red, yellow, blue and white.

Objectives

- To observe chromatophores which contain the black pigment melanin.
- To identify and draw the chromatophores on fish scales.
- To observe the effects of KCl and NaCl on chromatophores.

Materials

- Compound microscope
- Glass slide
- Cover slip
- Forceps
- Seawater
- A living Gulf Killifish, **Fundulus grandis,** or other fish
- .1M or .2M solution of NaCl and KCl.
- Medicine dropper

Processes: **Student Discovery Activity**

Part I. **Observation of chromatophores**

1. With a net, obtain a killifish or similar fish from the aquarium.
2. Envelop the fish with the net and place it on the table with a portion of its side showing. **Work as quickly as possible.**
3. Try to keep the fish from flailing.
4. With a pair of forceps, remove two or three scales from the side of the fish.
5. Try to remove two of the scales from under the pectoral fin and the other scale from the back.
6. Return the fish to its original aquarium.
7. Place all **three** scales on a glass slide, add a drop of seawater, and cover slip.
8. Place slide on the stage of the microscope. Make sure the **bottom** of the slide is dry. If saltwater remains on the stage it will cause the metal parts to corrode.
9. Observe scales on **low** power.

Observing 10. Where are dark star-shaped structures found?

11. Now observe scales on **high** power.

Observing 12. How is the pigment in the chromatophore distributed?

Communicating	13.	Draw two chromatophores.
Observing	14.	Do you notice other colored bodies on the fish scales?
Observing	15.	What colors do you find?

Part II **Addition of Chemicals**

	1.	Place a drop or two of .1M or .2M NaCl at one edge of the cover slip on a slide.
	2.	Place a folded paper towel on the opposite edge of the cover slip to draw the seawater and NaCl under.
	3.	Observe the chromatophore under **high** power.
Predicting	4.	What do you think will happen to the chromatophore?
Observing	5.	What did happen?
Communicating	6.	Draw a couple of chromatophores.
	7.	Repeat steps 1 through 6 with a solution of .1M or .2M KCl.
Predicting	8.	What do you think will happen to the chromatophore?
Observing	9.	What did happen?
Communicating	10.	Draw a couple of chromatophores.
Comparing	11.	Compare step 5 with step 9. What do you notice?
Inferring	12.	What shade would a fish become if the melanin in its chromatophores changed from a dispersed pattern to a concentrated one?
Inferring	13.	What shade would a fish become if the melanin in its chromatophores changed from a concentrated state to a dispersed state?
Hypothesizing	14.	What do you think would happen to a fish if it had no chromatophores?

Color Changes in Fish Scales
Post-Lab

Possible Answers to Questions

Part I. Observation of chromatophores:

10. These are chromatophores which are found toward one end.
12. Answers will vary.
14. Yes
15. Orange and other pigments may be present on the scale. However, the microscope must be carefully focused and the diaphragm adjusted to observe these crystals or bodies.

Part II. Addition of chemicals:

4. Answers will vary.
5. The pigment is dispersed in the chromatophores when .1M or .2M of NaCl is added.
6. Drawings should have chromatophores scattered or dispersed.
8. Answers will vary.
9. The KCl should cause the melanin to be concentrated in the chromatophores.
10. These drawings should show the chromatophores in a more concentrated state than the drawing in answer 6.
11. The students' responses should include the answer listed above in steps 5 and 9.
12. The fish would be **darker** in color.
13. The fish would be **lighter** in color.
14. The chromatophores protect the fish from predators. They permit the fish to blend into its environment.

Discussion

Discuss how colors can be beneficial to a fish. For example, colors can attract attention as well as be a device to avoid attention. Bright colors can be used to attract a mate or be used to warn possible predators to leave them alone. This type of behavior is important for survival.

Evaluation

All students should be able to draw a chromatophore. The ability to observe the effects of the chemical ion on the chromatophores will vary depending on the amount of solution that diffuses to the scales. Therefore, the students' responses will vary.

Follow-Up

- "A Close Look at the Grass Shrimp" activity.

References

Barnes, Robert D. Ph.D. **Invertebrate Zoology**, Second Edition. Philadelphia: W. B. Saunders Co., 1968.

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House Hunting Crabs

Level: 7-8

Pre-Lab

Concept

- Animal behavior

Facts

- Hermit crabs live a solitary lifestyle.
- Hermit crabs must protect themselves by means of borrowed protection, namely a gastropod shell.
- Hermit crabs have a soft external body covering.
- Shells are selected on basis of hermit crab's developing body size.

Suggested Prerequisite Skills

- Student must be able to use a drill and bit properly to drill a hole.
- Student must be able to apply gentle pressure to a gastropod shell in drilling a single hole so as not to hurt the animal being studied.

Student Performance Objectives

- Given many gastropod shells, the student will learn to select those which will develop an experimental situation for a hermit crab behavior study.
- By presenting various shells to a hermit crab, the student will observe a selection process develop.
- Given a drill and bit, the student will drill a hole into a hermit crab's shell without hurting the animal.
- By watching more than one hermit crab, the student will decide if a definite pattern of selection occurs.

Materials, Times, Cautions

- This activity will take at least one class period, perhaps more if you wish to extend the variations.
- Electric drills may be used; however, a hand drill will also serve the purpose. (One will suffice.)
- Caution the students to be careful when drilling the hole in the inhabited shell to be sure:

  it is positioned well enough back on the shell to be behind the animal;

  it penetrates only slightly, so the bit doesn't drill right into the crab and kill study subject.
- This activity may be done by two students working together in a team.

Definition of Terms

Gastropod — A stomach-footed mollusk having a single, coiled shell.

House Hunting Crabs
Student Lab

General Information

The hermit crab is a very active and hardy animal which is quite common in bays and other inland estuary areas of the coast. By their very nature they are scavengers and feed on bits and pieces of discarded food and other organic materials. The hermit crab depends on an empty shell to serve as its home. This crab has a very soft body covering which forces it to use empty gastropod shells for a protective body cover from its predators. The crab never leaves its shell unless to find a larger shell to contain its body size. Thus periodically they must switch from shell to shell.

Objectives

- To gain knowledge of the behavior patterns of the hermit crab as it relates to shell selection.

Materials

- Hermit crabs
- Shallow plastic pan
- Drill with small 1/8" bit
- Flat toothpick
- Seawater
- Two empty gastropod shells

Processes

Student Discovery Activity

1. Select a hermit crab in its shell and prepare to remove the shell.
2. Place the shell on a paper towel on your work table and drill a little hole in the shell at a point where his abdomen is located. The hole should be small to allow a flat toothpick to enter.
3. Insert flat end of toothpick and move it gently around inside, without hurting the crab, to cause the crab to fall out of his shell. Allow the crab to fall into a shallow plastic pan containing seawater.

Observing
4. What does the rear end of the crab's body look like? Describe.
5. Make sure the crab remains in seawater.

Inferring
6. Why should the crab be in seawater?
7. Select two empty shells, one the same size as the original and one either larger or smaller. Number each shell on top with pencil to identify it.
8. Place your empty shells in opposite corners of the pan, and your crab in a third corner.

Observing
9. What behavior does the crab display after you place him in the corner of the pan?

Measuring
10. How much time did it take for the crab to make his selection?

Observing
11. Which shell did the crab finally select?
12. Remove the crab from the shell it selected and place the crab and shell back in their original positions. Allow the crab to select a shell again. Which was selected the second time?

Observing	13.	This time present the crab with two larger shells and allow the crab to again select a shell. Describe what happens.
Hypothesizing	14.	What behavior will the crab display if you present him his original shell which fits, but place a paper plug in the inside?
Observing	15.	Allow the crab to find his own shell with the plug and watch what he does. Describe his actual behavior.
Observing	16.	Repeat steps one through 16 above using a different hermit crab. How does this crab respond to his new situations?
Comparing	17.	From what you observed, did the two crabs behave in similar or dissimilar ways?
Inferring	18.	How does a hermit crab select a shell for a home?
	19.	Return the crab to its proper shell and environment at the conclusion of this activity.

House Hunting Crabs
Post-Lab

Possible Answers to Questions

4. The rear of the hermit crab appears as a slender, some-what coiled projection, tapering to a blunt end. The rear is covered by a thin outer covering, not the usual hard coating found on the exterior of the claws.
6. The crab is kept in seawater because the animal must coat its gills with water to maintain sufficient oxygen levels for life.
9. The behavior displayed will vary based on individual situations.
10. Time will vary, but animal should hasten to find protective cover soon.
11. Hermit crab will probably select one which will accommodate his body.
12. During second trial, crab may still show a random selection process.
14. Crab will select either, but may show difficulty controlling the oversize shell.
15. The crab will immediately select his own shell but will display obvious discontent with the obstruction blocking this chamber.
16. Response in question fifteen should be confirmed.
17. Observations should prove similar to those already obtained, or at least similar.
18. Some similarities and some differences will be evident as different individuals were used as experimental subjects.
19. Hermit crabs select their shells on the basis of their body size at the present, and if it affords them adequate protection from their predators. Also, whether or not they can control the size of the shell with their body muscles is a determining factor.

Discussion

This is a very good activity in which to study animal behavior and the need for protection. Students should have reasonable success with the activity, and should see a definite tendency on the part of the crab to make certain selections.

Evaluation

You should expect reasonably good success with your students. Many of the student responses will vary but this is to be expected.

Follow-Up

You may wish to survey the entire class for collective responses to attempt to establish a pattern of behavior.

Hide and Seek

Level: 7-8

Pre-Lab

Concepts

- Cryptic coloration
- Passive protection
- Structural and behavioral adaptations

Suggested Prerequisite Skills

- None

Student Performance Objectives

- Student must be able to describe the physical (structural) and behavioral adaptations which allow flounder to effectively blend with their environment.
- Student must be able to explain what is meant by cryptic coloration (camouflage) and provide at least **one** example of another organism which uses this adaptation to aid its survival as a predator or prey.

Materials, Time, Cautions

Materials

- Marine aquarium with a sandy bottom
- Glass bottom aquarium or large culture dish with cover
- One or more flounder per class
- Dip net
- Patterned sheets of paper to fit under the glass bottom aquarium (try small checks or spots with a contrasting background; try various colors - a different combination for each fish)

Time

- Two days - 30-40 minutes on the first day and 15-30 minutes the second day

Cautions

Depending on the number of fish and the size of the glass bottom aquarium, you may want to use plastic partitions to separate the fish. If the fish are small enough, the large culture dishes may be more convenient if covered to keep the fish from jumping out. **Remember**: **Do not** clean out containers with soap or detergents.

Definition of Terms

Camouflage	Any means of blending with environment
Cryptic coloration	Camouflage by coloration
Passive protection	Protection provided by physical characteristics of an organism rather than behavioral, which would require active involvement of an organism

Hide and Seek
Student Lab

General Information

Some animals are able to survive better because they can blend in with their environment or are camouflaged. Animals which are camouflaged by cryptic coloration have color patterns which blend in with their environment. Such protection is passive because it does not require active participation of the animal.

Structural adaptations may further enhance the effectiveness of cryptic coloration. Behavioral adaptations also may enhance the effect and provide active protection.

Objectives

- To observe the ability of flounder to change their coloration patterns to blend in with their environment.
- To observe the physical (structural) and behavioral adaptations which allow flounder to camouflage themselves effectively.
- To provide examples of how different predators and prey use cryptic coloration to their benefit.

Materials

- Marine aquarium with sandy bottom
- Glass bottom aquarium or large culture dish (covered)
- Small flounder
- Dip net
- Patterned paper (small spots or checks with contrasting background)

Processes		Student Discovery Activity
Communicating	1.	Observe the flounder in the aquarium with the sandy bottom. Describe what the flounder has done to blend in with its environment.
Communicating	2.	Carefully transfer the flounder with the dip net to the glass bottom aquarium or culture dish. Describe the physical adaptations which enable the flounder to better blend in with its environment. (You may want to look through the bottom of the aquarium).
Observing and communicating	3.	Place the dish on the patterned paper. Observe the next day and describe any changes in the appearance of the fish.
Comparing	4.	If other fish are available, compare the ability of flounder to match different backgrounds effectively.
Communicating	5.	Write a paragraph or two about physical and behavior adaptations of flounder which enable them to blend in with their environment. How effectively can they camouflage themselves?
Applying	6.	Give specific examples of other predator and prey organisms which use cryptic coloration to their benefit.
	7.	Return the flounders and fish to their proper environment at the conclusion of the activity.

Hide and Seek
Post-Lab

Possible Answers to Questions

1. The color blends with background; flounder may be buried in sand.
2. The flounder's body is flattened with both eyes on one side of its body. Coloration is on the top side of the body only (color is not needed on underside).
3. Pattern should approximate background.
4. Matching will vary according to background.
5. Answers will vary.

Discussion

Ask the students the following questions at the end of the activity:

1. How is cryptic coloration adaptive to a predator? Prey?
2. Does man ever use cryptic coloration to his benefit? (camouflage war gear)

Evaluation

The following four questions could be used as a writing exercise.

1. Define the following terms and provide a specific example of each:
   a. camouflage
   b. cryptic coloration
   c. physical adaptation
   d. behavioral adaptation
2. Many organisms are cryptically colored but cannot change their coloration to match different backgrounds. How effective are flounder in matching their coloration to their environment?
3. What are some other adaptations which improve the effectiveness of the flounder's camouflage?
4. Explain why flounder do not have pigment on their undersides and cannot change the coloration of this side.

Follow-Up

- What is the role of sight in this color change process?
- Can the chromatophores (color cells) be seen under dissecting scope?
- How long does the color change take?

References

Oram, Raymond F., Hummer, Paul J., Smoot, Robert C. **Biology: Living Systems.** Columbus: Charles E. Merrill Publishing Company, 1976.

Otto, James H., Towle, Albert. **Modern Biology.** New York: Holt, Rinehart and Winston, Inc., 1969.

Beach Fleas or Sandhoppers

Level: 7-8

Pre-Lab

Concept

- Life in a beach habitat

Facts

- Amphipods, sandhoppers or beach fleas are crustaceans.
- Amphipods are only found in the beach area.
- Amphipods respond to diurnal stimuli and tidal rhythm.
- The organism burrows in the sand during the day at high tide and emerges at night at low tide.

Suggested Prerequisite Skill

- Students must be able to plan their daily schedules to observe these organisms.

Student Performance Objectives

- Students should be able to duplicate a beach environment in a small aquaria.
- Given many amphipods. the student will be able to record their behavior response to physical factors.
- The student should be able to relate the amphipods' behavior to possible conditions in nature.

Materials, Time, Cautions

Materials

- Aquaria (1 gallon) or bowls
- Beach sand
- Baggies or jars
- Black construction paper or tin foil
- Fine mesh screen
- Light source
- Dip nets

Time

- 10 minutes per day for one week

Cautions

- The students' aquaria containing sandhoppers must be covered with a fine mesh screen.
- Some beach debris can be kept in the refrigerator in plastic bags and used for a food source for several days. Amphipods can be found in the plankton of the open water occasionally, but most of them are benthic, on rock, in barnacle masses and mud mats.

Definition of Terms

Amphipods	Beach fleas or sandhoppers
Diurnal	Day time
Nocturnal	Night time
Tidal rhythms	High and low tide
Flotsam	Floating material, debris

Beach Fleas or Sandhoppers
Student Lab

General Information

One of the most widespread and effective beach-cleaning organisms is the crustacean group of amphipods usually called sand hoppers or beach fleas. These creatures are inbetweens in the evolutionary change from sea to land dwellers. They don't swim, respire or reproduce in the open water, in fact they will drown if submerged too long. They are never found far away from the sea, however. They are burrowers by day and some burrow in response to tidal rhythms. During the night they search for decomposing organic matter. They consume large volumes of beach debris.

In the beach area of pounding waves, shifting sands, tides and exposure, the environment is highly stressed and there are not many species adapted to survive there. Those that do may occur in large populations. Thienemann stated that the more extreme the habitat, the poorer in species it will be, but the richer in individuals. The sandhopper is well adapted for the beach habitat.

Objectives

- To determine the effects of light, darkness and moisture on a population of beach fleas.

Materials

- Three 1-gallon aquaria or bowls per student or team
- Beach sand
- Baggies or jars
- Black construction paper or tinfoil
- Fine mesh screen
- Light source
- Dip net

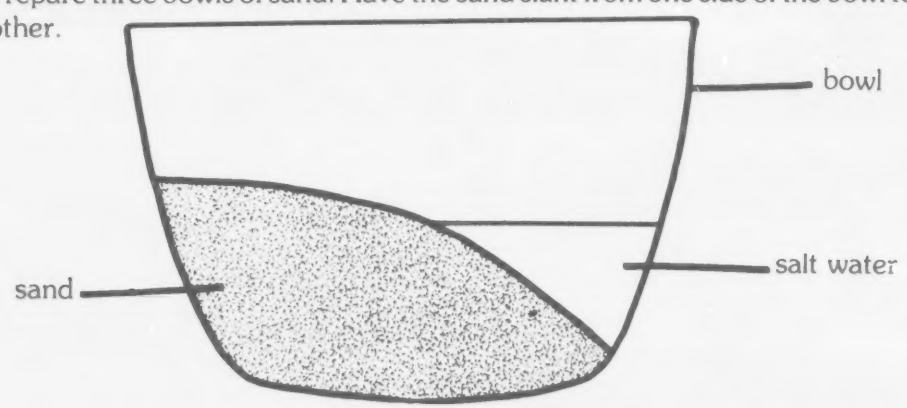
Processes

Student Discovery Activity

1. Obtain a pile of seaweed and flotsam found on the beach.
2. Catch, with a dip net, the beach fleas or sandhoppers jumping around.
3. Place the sandhoppers in a baggie or jar with damp sand.
4. Punch a few tiny holes in the jar lid or baggie.
5. If you cannot do your own collecting, your instructor will provide you with a group of them.

Measuring

6. Prepare three bowls of sand. Have the sand slant from one side of the bowl to the other.



	7.	Place saltwater in the bowl on the side where the sand layer is shallow. **Do not** put so much that all the sand gets wet.
	8.	Place a few sandhoppers in the bowl, and some beach debris. Cover it immediately with a piece of fine screen mesh.
	9.	Place one bowl in full light.
	10.	Cover one half of another bowl with black construction paper or tin foil.
	11.	Cover another bowl **completely** with foil and punch tiny pin holes to insure gas exchange.
	12.	Observe each bowl over several days.
Observing	13.	Where do the beach fleas burrow?
Inferring	14.	What evidence do you have that beach fleas did something?
Comparing and observing	15.	How does the life found in one aquarium, or bowl differ from that found in the half covered bowl and with the bowl completely covered?
Comparing and observing	16.	Compare the burrows found in all three bowls. How are they different?
Describing	17.	Add more saltwater to the habitats. How has this addition of saltwater affected the behavior of beach fleas?
Observing	18.	What kinds of conditions do beach fleas need to survive in their natural habitat?
Hypothesizing	19.	What do you think would happen to beach fleas if you left them in a dry sandy environment without saltwater?
Hypothesizing	20.	What do you think would happen to the beach fleas if you used tap water rather than saltwater in this activity?
Applying	21.	Why do you think beach fleas are important?
Hypothesizing	22.	What do you think would happen to the laboratory raised fleas if you released them into their natural environment?
	23.	How could you prove that beach fleas raised in the laboratory and released into their natural environment travel greater distances than those found in the natural environment?
	24.	Return beach fleas to their proper environment at the conclusion of the activity.

Beach Fleas or Sandhoppers
Post-Lab

Possible Answers to Questions

13. Answers will vary.
14. Beach fleas will make burrows.
15. Answers will vary.
16. Answers will vary.
17. Beach fleas cannot build burrows in wet sand.
18. Sandhoppers burrow in dry sand during the day (at high tide) and move around at night (during low tide). They eat organic debris or detritus.
19. This depends on the length of time they are left in the habitat. The longer they remain in a dry habitat the more they are susceptible to desiccation.
20. Answers will vary.
21. Beach fleas are important in beach ecology. These scavengers consume large amounts of decomposing organic debris and break down piles of seaweeds and flotsam found on the shore line.
22. Not a thing.
23. Herrnkind reported that laboratory raised beach fleas travel greater distances than those collected in the field and would need time to adjust to their new surroundings.

Discussion

Students should experience reasonable success with the activity. The student should see a lot of activity on the sand in the covered habitats and should notice burrows in the noncovered habitat.

Evaluation

A few of the students' responses will vary but this is to be expected. Encourage students to think of other creatures that are "part water, part land" adapted. An example is the isopod (pill bug or sow bug).

Follow-Up

You may wish to survey the entire class for collective responses to attempt to establish a pattern of behavior. Another beach scavenger is the ghost crab. If these are available the experiment can be done with them, however, the crab must have water to wet his gills and the containers must be larger.

Reference

Herrnkind, William F. "Orientation in Shore-living Arthropods, Especially the Sand Fiddler Crab." In **Behavior of Marine Animals. Vol. I: Invertebrates.** pp. 1-7. Edited by Howard E. Winn and Bori L. Olla. New York: Plenum Press, 1972.

Snails "on the Move"

Level: 7-8

Pre-Lab

Concept

- Locomotion in mollusks

Facts

- Snails are members of the group called mollusks.
- Marine snails are single-shelled, or univalve, mollusks.
- Snails have a flat, muscular foot on which they travel.
- When touched, a snail's body is drawn in and seems to vanish.
- Snails seal themselves off from predators by means of a trapdoor, or operculum, which closes the shell from the outside.

Suggested Prerequisite Skills

Students must be able to:

- Read a grid in multiples of $5mm^2$
- Solve a problem by division
- Compute an average
- Do a pencil sketch from a live object

Student Performance Objectives

- Given a live snail, locate and identify the foot.
- Given the needed materials, compute the speed of locomotion of a single snail.
- Given speed data from several students, compute the average speed of locomotion for a marine snail.

Materials

- One oyster drill snail for each student
- Plastic petri dish bottoms are recommended; however, any clear plastic pan is acceptable
- Watch or clock with a second hand

Snails "on the Move"
Student Lab

General Information

Locomotion is an important process in the marine world. The methods used are quite diverse; some organisms propell themselves by fins and others must crawl. Most marine snails must crawl to move from place to place. Snails belong to the group of mollusks called gastropods or "stomach-footed" animals. The marine snail is a good mollusk to study because it is obtained easily and moves around freely while being observed. Movement is accomplished by rhythmic, wavelike contractions of the foot muscles.

Objectives

- To locate and identify the structure of locomotion in the marine snail.
- To observe the flowing motion of the marine snail.
- To compute the speed at which marine snails move.

Materials

- Live oyster drill snail (**Thais haemostoma**)
- Toothpick
- Plastic petri dish bottom
- Seawater
- Watch with second hand

Processes	Student Discovery Activity
	1. Place about 3mm of seawater in the bottom of a clean petri dish.
	2. Slide dish on top of premeasured grid-graph.
	3. Place live snail in center of dish and allow it to adjust to new environment.
Observing	4. What does the snail use to move itself from place to place?
Observing	5. Describe the physical appearance of the structure of locomotion.
Predicting	6. How do you think this animal will respond to a disturbance in its path?
	7. Take a clean toothpick and touch the structure of locomotion as the snail attempts to move forward.
Observing	8. Describe the actual response generated by your touching the snail.
Observing	9. Did the shape of the structure of locomotion change when it was touched? Describe.
	10. Align the snail so it will move from one side of the dish to the other.
Measuring	11. Determine the time it takes for the snail to cross the dish. Several tries may be needed before you get a good time. How long did it take the snail? Use the leading edge of the snail for your measurement.
	12. Compute the snail's speed by using the following formula: $\frac{\text{length of dish bottom in mm}}{\text{time to travel distance in seconds}} = \text{speed in mm/s}$
Graphing	13. Record your snail's speed and those of other classmates' snails in the table below.

Table 1. Individual and Class Speeds

	Snail Speed
Your data	
Student 1	
Student 2	
Student 3	
Student 4	
Student 5	
Total	
Average	

Communicating 14. From your average data, compute how long it would take the snail to travel one meter.

15. Pour off some of the water and watch the snail move from beneath the clean dish.

Observing 16. Describe what you see from the underside of the snail.

Inferring 17. Why is the foot important? Describe the snail's coordination attempts with its foot.

Observing 18. Tap the snail on its shell with a pencil to get it to stop. Pick the snail up. What response does this generate? Describe.

19. Replace the snail in the dish. When the snail is fully extended, draw a pencil sketch below which shows the snail in motion and fully extended. Label the shell and foot.

Communicating 20. Return the snail to its normal habitat in the lab and clean up all equipment used.

Snails "on the Move"
Post-Lab

Possible Answers to Questions

4. The snail uses its stomach-foot to glide over the surface.
5. The snail's foot is flat and thin with a somewhat rounded outer border or perimeter. The leading, or forward, edge is visible when in motion.
6. Student predictions will vary.
8. The snail probably will stop when it encounters the toothpick, sense what it is and then take evasive measure to move around it. Some snails may retreat.
9. A slight indentation occurs where the foot encounters the toothpick.
11. Individual answers will vary.
13. Answers will vary.
14. Answers will vary.
16. The foot resembles a smooth, flat oblong disk with a distinct heading edge and trailing edge.
17. Close study may reveal wavelike coordinations of the foot muscle.
18. The snail hesitates when tapped. When picked up, the snail begins to retreat into its coiled shell, sealing off the tender foot by a flat, circular-shaped trapdoor or operculum.

Discussions

Most students should obtain reasonably good data, although some snails may not respond as favorably as others. The snails will exhibit random movement. Slow or non-mobile snails may be encouraged by a small morsel of shrimp meat.

Evaluation

The answers obtained from Table 1 should be reasonably good. Values will vary due to the different conditions of the snails used for the experiment. All students should provide a good sketch of their snails.

Follow-Up

Locomotion studies can be extended to obtain a more accurate speed for the snail.

An incentive, in the form of food, can be placed at opposite ends of the dish. Allow the snails to search out the food source, determine their speed and compare this to previously obtained results.

A Close Look at the Grass Shrimp

Level: 7-8

Pre-Lab

Concept

- Anatomy

Facts

- The grass shrimp is a common invertebrate in estuaries.
- The external and internal anatomies are quite similar to the crayfish.

Suggested Prerequisite Skills

- Students should have a general knowledge of crayfish external anatomy or have books available for reference.
- Students must be able to use a dissecting microscope.

Student Performance Objectives

- Given a grass shrimp, the student will be able to identify it.
- Given data, the student will be able to correlate the external anatomy of a crayfish to that of a grass shrimp.
- Given data, the student will be able to identify certain major internal structures in a living grass shrimp.
- Given information, the student will be able to distinguish between a Caridean shrimp (grass shrimp) and a Penaeidean shrimp (commercial eating shrimp).

Materials, Times, Cautions

Materials

- A grass shrimp
- A petri dish
- Seawater
- Dissecting scope

Times

- 30 minutes

Cautions

- **Do not** allow seawater in petri dish to become too hot during the activity. It will kill the shrimp. Have students turn off lamp **any** time it is not is use. Remove the petri dish from the scope if the student is not viewing for a 5-minute, or longer, time period.

A Close Look at the Grass Shrimp
Student Lab

General Information

Transparent grass shrimp are found in the shallow marine waters of the coastal estuaries. This invertebrate, which occurs in numerous quantities, takes refuge from predators among the plants at the water's edge. Like its cousin the commercial shrimp (which many of us love to eat), the grass shrimp is a scavenger. That is, they eat any bits of food laying around. Grass shrimp are found most abundantly in salinities from 10 o/oo to 20 o/oo. The females attach their fertilized eggs to their abdominal appendages (pleopods). As the shrimp swims, the movement of the pleopods aerates the eggs and cleans the detritus from them. Spawning occurs in July and October.

Objectives

- To identify a grass shrimp.
- To correlate the grass shrimp's external anatomy to that of a crayfish.
- To identify certain internal structures.
- To be able to tell the difference between a grass shrimp and a commercial shrimp.

Materials

- Grass shrimp in a marine aquarium
- Petri dish filled with seawater
- Dissecting scope

Processes — Student Discovery Activity

Observing

1. Observe a grass shrimp at rest.
2. Observe a grass shrimp moving.
3. Label the two drawings below. Label one "brokenback" grass shrimp and the other a commercial shrimp.

Communicating

4. Label the following on the shrimp drawings: cephalothorax, abdomen, abdominal appendages (pleopods), antennae, rostrum.
5. Catch a grass shrimp from your aquarium with a small dip net and place it in a petri dish full of water.

Observing

6. Using a dissecting microscope, observe the dorsal (back) surface of the shrimp. **Caution - Do Not** allow sea water to become warm while observing.
7. Turn off lamp when the microscope is not in use.
8. Remove petri dish from the scope if it has not been used for 5 minutes or more.

9. Look through the dissecting microscope and answer the following:

Observing — a. What structures on the shrimp can you see?

Observing — b. What external structures on the head are visible?

Observing — c. Can any internal structures be identified?

Inferring — d. What do you think they are?

Observing — e. Find the pulsating internal structure in the thoracic area. Name it.

Inferring — f. Why is it light colored?

g. Identify the large dark internal structure. Name it.

Observing — h. Is it darker than the pulsating one?

Inferring — i. What is its function? Note a long internal structure(s) which runs from the thoracic area to the end of the abdominal region.

Observing — j. What is this structure?

Inferring — k. What is its function?

Observing — l. Find the large dark structure which seems to be beneath the pulsating one. Its function is reproductive. Name it.

Communicating 10. Draw a grass shrimp and identify as many internal structures and their functions as you can.

A Close Look at the Grass Shrimp
Post-Lab

Possible Answers to Questions

9. a. Antennae, rostrum, walking legs, pleopods
   b. Antennules
   c. Yes
   d. Answer will vary
   e. Heart
   f. Because its blood isn't dark
   g. Stomach
   h. Yes
   i. Digestion
   j. Intestine, possibly dorsal abdonimal artery
   k. Digestion, circulation
   l. Gonad (testis, ovary) or digestive gland

Discussion

Ask students the following questions at the end of the activity:

1. Why is the grass shrimp transparent?
2. How would this be an advantage?

Evaluation

The three questions which follow could be used as a writing experience.

1. In what ways (external features, life style, habitat) are the grass shrimp and the crayfish similar?
2. In what ways are they different?
3. The legs on which region are used for walking?

Follow-Up

See Grass Shrimp Temperature and Feeding activity.

References

Barnes, Robert D. **Invertebrate Zoology,** 3rd Edition, Philadelphia: W.B. Saunders Co., 1974.

Fotheringham, N. and Brunenmeister, S. **Common Marine Invertebrates of The Northwestern Gulf Coast,** 2nd Edition, Houston: Gulf Publishing Co., 1975.

Meglitsch, Paul A. **Invertebrate Zoology,** New York: Oxford University Press, 1967.

How to Catch Attachers

Level: 7-10

Pre-Lab

Concept

- Some animals live attached to a substrate and some do not.

Facts

- Many aquatic organisms are adapted to attach themselves to solid substrates.
- The ability to attach protects organisms from water movements such as currents and waves.
- When plant life attaches to solid objects, it serves as a food supply for animal life.
- Microslides can be suspended in aquaria filled with natural seawater collected on a field trip, or in quiet, protected tidal pools in the field.
- Manmade objects in the sea (oil drilling platforms, artificial reefs, etc.) often attract many attaching organisms.

Suggested Prerequisite Skills

- Students should be acquainted with the principal groups of microscopic marine algae and small marine animal life.

Student Performance Objectives

- Given different samples of seawater, students will find marine organisms attaching themselves to solid objects.
- Given different slides, students will determine whether the attached marine organisms are producers or consumers, and which ones serve as food for marine predators and grazers.

Materials, Times and Cautions

Materials

- Small aquaria or plastic dishpans
- Natural seawater
- Microslides
- String
- Clay
- Dowel stick rod
- Fluorescent or gro-light source
- Microscope
- Air pump
- Tubing and air stones

Time

This exercise can be set-up in a 30-minute period. Examination of slides should take place every two or three days for a month.

Cautions

- The natural seawater should be collected from an area near the shore where there are solid substrates.
- A fresh supply should be added every other day to remove decomposing products and introduce new possible "attachers".
- **Do not** use a filter.
- Small sheets of plastic or neoprene can be substituted for glass slides but they must be washed or scraped to examine through a compound microscope.

Definition of Terms

Substrate	Surface on which or in which an organism lives.
Producer	Green plant capable of performing photosynthetic food production.
Consumer	An organism incapable of its own food production which must take in food by predation or filter feeding.
Detritus	Loose material that results from rock disintegration.
Predator	An organism that lives off and at the expense of others.
Grazers	An organism that continually lives off another organism.

How to Catch Attachers
Student Lab

General Information

Many marine organisms are adapted to attach themselves to solid objects or surfaces called the substrate. This provides protection against the many water movements such as currents, the pounding of waves, etc.

Photosynthetic plants which attach to solid objects (piers, boats, rocks on the shoreline, etc.) serve as food for animal life, some of which also is attached, or which crawls over the substrate; burrows into it, or grazes on the attached organisms as they swim in the water nearby.

Objectives

- To observe which marine organisms attach themselves to a solid substrate.
- To determine from the solid substrate, which organisms are producers and which are consumers.

Materials

- Small aquaria or plastic dish pans
- Natural seawater
- Microslides
- String
- Clay
- Fluorescent or gro-light
- Microscope
- Air pump
- Tubing
- Airstones

Processes

Student Discovery Activity

1. Place a supply of recently collected natural seawater in a small aquarium or plastic dish pan.
2. Put a dowel stick across the aquarium and keep it in place with a small portion of clay.
3. Suspend two or three slides from the dowel so that they almost, but do not actually, touch the bottom.
4. Place an air source in the aquarium, operating low enough so the water is not agitated and the slides do not hit each other or the container.
5. After 48 hours, remove the slides from the tank.
6. Cover the slides with one large or several small cover slips and examine through a compound microscope.

Observing

7. How soon did you notice material sticking to the slides?
8. Record the types of organisms you find and state whether they are **producers** (example, diatoms, blue-green and green algae) or **consumers** (example, stalked ciliates, nematodes, rotifers, etc.)

Observing	9.	Was the material living organisms or just detritus?
Predicting	10.	What type of living marine organisms do you think you will find?
Comparing	11.	Compare the plant life with the animal life. Which one did you find more of, plant life or animal life?
Inferring	12.	What forms of marine life do you think use the attached organisms as food?
	13.	Remove about half the seawater from your tank every two to three days and add fresh seawater.
Inferring	14.	Why do you think an oil drilling platform attracts many marine organisms?
Designing an experiment	15.	Design an experiment to find out which type or texture of substrate attracts different organisms. Does a rough or smooth surface attract more?

How to Catch Attachers
Post-Lab

Possible Answers to Questions

7. A few organisms will attach themselves fairly soon but in most cases there should be a large number attaching themselves to the substrate (side) within 48 hours.
9. Some material on the slide may be crystals and detritus.
11. This answer will vary, depending upon where the source of seawater was collected. Sometime the seawater will contain mostly diatoms, sometimes blue-green algae, and on other occasions colonies of stalked ciliates.
12. Worms, copepods and small fish.
14. Attached organisms on a drilling rig platform serve as a source of food to fish. Also, some "hiding places" are created by platform structures.
15. Answers will vary.

Discussion

This activity may be unsuccessful several times but very successful the next! It depends on the type of organisms present in the water you collect. If it is collected near a rocky shore (artificial rocky area such as groins, jetties, etc., or an oyster reef) there will be sufficient microorganisms to demonstrate a small community of attached organisms within a few days.

If the slides do not have too much marine life visible, collect the material on the sides or bottom of the aquarium. Scrape and examine these masses - they are organisms which would be found attached in the natural seawater habitat.

Follow-Up

Repeat this activity but change the variables:

1. Use different materials as suspended substrates.
2. Change the texture and size of the substrate.
3. Change the temperature of the seawater and the amount of light that penetrates the water.

How Salty Can They Take It?

Level: 7-12

Pre-Lab

Concept

- Some organisms in nature can adapt to different environments.

Facts

- The guppy can adapt to a salt water habitat.
- The change-over has to be gradual.

Prerequisite Skills

- Students should be able to determine salinity with a hydrometer, determine pH, read a thermometer, make a chart and record observations daily.

Student Performance Objectives

- Given different salinities, the student will determine the survival rate of several guppies.

Materials, Time, Cautions

Materials

- Five 20-gallon aquaria with covers (four fresh water, one seawater - may be obtained from ocean or use Instant Ocean)
- 40 guppies
- One hydrometer with thermometer
- One 100 ml beaker
- One chart to record daily salinity, pH and temperature
- Heaters may be necessary depending on what time of year this activity is done.

Time

Allow just enough time each day for groups to take readings and make observations and record them (approximately 10 minutes) for eight weeks.

Cautions

The pH and temperature must be kept as constant as possible as too low a temperature will kill the guppies. Seawater should be from an open body of water and not from an enclosed bay.

All readings and observations should be made at the beginning of each period before taking or adding water to the tank. The heaters should be calibrated before starting activity.

Be sure to follow the basic safety standards.

Definition of Terms

pH	The number of hydroxyl ions (OH^-) a base, or hydrogen ions ($H+$), an acid, in solution.
Salinity	Amount of dissolved salts in water, usually expressed in parts per thousand (o/oo) e.g., the number of grams of salt in 1,000 ml of water is the salinity.
Aerate	Expose to and mix with air.

How Salty Can They Take It?
Student Lab

General Information

The guppy is a hardy organism that can be found in at least one aquarium in a classroom. It reproduces rapidly; this makes it a good organism to experiment with in the lab.

Objective

- To determine if it is possible for a fresh water organism to change to a saltwater organism.

Materials

- One hydrometer w/thermometer
- One set of corresponding Densities and Salinities charts
- pH paper
- Five 20-gallon aquaria with air supply and covers
- 40 guppies
- Fish food
- Chart to record daily salinity, pH and temperature of each aquaria

Processes **Student Discovery Activity**

1. Divide class into four groups. Each student should learn to record data and take hydrometer readings.
2. Each group should have five aquaria labeled A, B, C, D and reserve.

Measuring

3. Fill aquaria A, B and C with fresh water. Fill aquarium D with freshly made seawater or water collected from the ocean and fill the reserve aquarium with seawater.
4. Aerate all tanks.

Measuring

5. At the beginning of the week make temperature, pH and salinity readings of all four aquaria.
6. Record your readings below.

Communicating

AQUARIUM #_____								
DAY	1	2	3	4	5	6	7	...40
TEMPERATURE								
pH								
SALINITY								
BICARBONATE OF SODA								
NO. OF GUPPIES								
COMMENTS:								

	7.	Place 10 guppies in tanks A, B, C and D.
Observing	8.	Observe the guppies each day and record your findings in the table adjacent to "comments."
Measuring	9.	Take temperature, pH, salinity and number of fish each day and place your findings in the table.
Controlling varibles	10.	**Take** 100 ml of water from aquarium A and throw away; then **add** 100 ml of seawater from the **reserve** aquarium to aquarium A.
	11.	In aquarium B **take out** 200 ml of water and discard it; then **add** 200 ml of seawater from the reserve aquarium to aquarium B.
	12.	In aquarium C **take out** 500 ml of water and discard it; then add 500 ml of seawater from the reserve supply to aquarium C.
	13.	Leave aquarium D alone. It will serve as a control.
	14.	Repeat steps 8-13 each day for eight weeks.
Comparing	15.	At the end of forty days compare aquaria A, B and C. What similarities or differences did you notice?
Predicting	16.	Do you think it would be possible to take a hermit crab **(Clibernarius vittatus)** and adapt it to a freshwater environment?
Observing	17.	Did the aquaria increase in salinity in the approximate ratio that the seawater replaced the fresh water?
Inferring	18.	Would the number of guppies be the same or less in aquarium A, B, C or D after 40 days of investigation? Why?
	19.	Do not stop working with your aquaria even if the guppies die.
Measuring	20.	If the pH becomes acidic, add bicarbonate of soda to the aquarium until the pH has been brought back to the 7-8 range.
Communicating	21.	Record the number of grams added to the aquarium on the table.
Measuring	22.	Keep the water temperature at 20°C, 24 hours per day.
	23.	At the end of the activity clean up the work area.

How Salty Can They Take It?
Post-Lab

Possible Answers to Questions

15. Aquarium C should increase more in salinity than aquarium A and B. Also aquarium B should increase more than aquarium A. Furthermore, aquaria A, B or C should not have the same salinity as that found in aquarium D.
16. Yes, if you take the crab through a gradual salinity change.
17. Close enough.
18. Aquarium A should still have most of its fish alive.
    Aquarium B 50/50 chance
    Aquarium C maybe 1 or 2
    Aquarium D probably none

Discussion

If these fish can change from fresh water to saltwater, perhaps other animals can make the same adjustment. Edible fish might grow faster in saltwater than in fresh water. This would increase the protein production in the world.

Evaluation

This activity will expose the student to the following laboratory techniques: measuring liquids; determining salinities; taking care of organisms; making observations; and recording data.

Follow-Up

Keep as many guppies alive as possible in saltwater and determine if they will reproduce.

References

Science Project Cards-Marine Science, "Salt Tolerance", Dr. John N. Fleming, The Center for Applied Research in Education, Inc., West Nyack, NY 10994, 1978.

Marine Science Handbook, Corpus Christi Public Schools, July 1978.

Oceanography-A Course of Study in Marine Science, Houston Independent School District, 1978.

Crab Diggers

Level: 7-12

Pre-Lab

Concepts

- Different crabs require different environments.
- Environmental factors affect crabs.

Facts

- The crab family Ocypodidae (Ghost crabs and fiddler crabs) exhibit burrowing behavior.
- Fiddler crabs are found in the salt marsh.
- Ghost crabs are found in the Gulf beach and fore-dune ridge areas.
- Crab burrowing is affected by light, moisture and substrate size.

Suggested Prerequisite Skills

- Students should be able to make a chart and record observations daily.
- Student must have patience.

Student Performance Objective

- Given the burrowing activity of crabs, the student will be familiar with several factors that affect it.

Materials, Times and Cautions

Materials

- Four - 35-liter aquaria with covers
- Four - plastic or glass A dividers
- Fine, medium, coarse grained sand and marine mud
- Black pepper
- Florescent lamp
- Four - small Ghost crabs
- Four - small Fiddler crabs
- Several screens of different mesh sizes
- Petri dishes

Time

This activity should take from three days to one week to complete.

Cautions

- Use only florescent lamps as incandescent lamps will dry out and overheat the organisms.
- By washing beach sand and silt with water and air drying and sifting it through a series of different mesh screens, substrate particles can be obtained. **Do not** speed through this process.

Definition of Terms

Substrate	The material on which an animal lives or moves or digs into.
Nocturnal	An organism that is active at night.
Terrestrial	An organism that lives on land.
Intertidal	An area alternately covered and exposed by tidal action.

Crab Diggers
Student Lab

General Information

The family Ocypodidae includes some of the most familiar amphibious crabs. For example, the Ghost Crab (**Ocypode quadrata**) and the Fiddler Crab (**Uca sp.**) are included in this group. Both types are burrowers, however certain differences are evident. The Ghost lives above the high tide mark near the fore-dune ridge area, thus, is mostly terrestrial, while the Fiddler lives in the salt marsh area and is intertidal. The Ghost is a nocturnal creature, while the Fiddler is active during low tide regardless of the hour.

Objectives

- To show that the burrowing behavior of the Ghost and Fiddler crabs vary with the presence or absence of light, moisture level of the substrate, and the grain size of the substrate.
- To show the differences in the burrowing behavior of the Ghost and Fiddler crabs.

Materials

- Four - 35 liter aquaria with covers
- Four - plastic or glass aquarium dividers
- Fine, medium, coarse grained sand and marine mud
- Black paper
- Florescent lamp
- Four - small Ghost crabs
- Four - small Fiddler crabs
- Several screens of different mesh sizes
- Crackers, bits of fresh fish, bread or dry dog food
- Petri dishes

Processes	Student Discovery Activity
	Part I - Light
	1. Label each aquarium 1, 2, 3, or 4.
Measuring	2. Half fill four 35-liter aquaria with **moist, medium** grained sand.
Measuring	3. Place a petri dish containing 35 percent seawater into each aquarium.
	4. Place a Ghost crab and a Fiddler crab in each aquarium with an aquarium divider separating the animals.
	5. Place a florescent lamp over aquaria 1 and 2 and completely wrap the remaining aquaria (3 and 4) with black construction paper.
	6. Turn on the florescent lamp and keep it on overnight.
Communicating	7. Record the results on your chart of burrow development of each crab in each aquarium.
Observing	8. Which light condition seems to be "best" for each crab?

Inferring	9.	Does your data support or contradict the information supplied under the heading general information?
	10.	Remove and return the crabs to their original environment.

Part II - Moisture

Measuring	1.	Half fill four 35 liter aquaria with **dry medium** grained sand.
	2.	Pour 35 percent seawater in varying amounts into aquaria 2, 3, and 4 from slightly moist to totally saturated.
	3.	**Note** aquarium 1 should have only dry medium grained sand and **no** water.
	4.	Place one Ghost and one Fiddler crab in each aquarium with a plastic divider between them.
	5.	Place all aquaria in **direct** sunlight and leave overnight.
Communicating	6.	The next day, record the results on your chart of the burrow development of each crab in each aquarium.
Observing	7.	What seems to be the optimum moisture level for each group?
Inferring	8.	Is this conclusion supported by the general information paragraph? Why or why not?
	9.	Remove and return the crabs to their original environment.

Part III - Substrate Size

	1.	Half fill four 35 liter aquaria with **substrates of increasing particle** size.
	2.	Aquarium 1 should have **fine mud.**
	3.	Aquarium 2 should have **fine moist** sand.
	4.	Aquarium 3 should have **medium** moist sand.
	5.	Aquarium 4 should have **coarse grain moist** sand.
	6.	Place one Ghost and one Fiddler crab in each aquarium with a divider separating them.
	7.	Place all aquaria in direct sunlight and leave overnight.
Communicating	8.	The next day, record on your chart the results of burrow development of each crab in each aquarium.
Observing	9.	Which substrate size seems "best" for each crab burrowing activity? Why?
Communicating	10.	List any noticeable differences in and around the burrows of each crab in their optimum condition.
	11.	Remove and return the crabs to their original environment.
Inferring	12.	Why do you think the names Ghost and Fiddler were chosen for these animals?
Observing	13.	Describe any unusual behavior exhibited, besides burrowing, by these crabs during this activity.
Summarizing	14.	What can you conclude about the Ghost and Fiddler crabs.
Design an investigation	15.	What could you do with a Ghost and Fiddler crab to see how territory size affects the burrowing activity?

Crab Diggers
Post-Lab

Possible Answers to Questions

Part I Light

8. Ghost digs more in light, less in dark. Fiddler is not affected by light.
9. **Ghost** - Florescent lamp should produce more burrowing away from light as this crab is nocturnal.
   Fiddler - light should not affect the burrowing of this animal as it relates to water level in the intertidal zone.

Part II Moisture

7. Very moist to wet for Fiddler crab, slightly moist for Ghost crab.
8. Supported by the paragraph under general information as the Fiddler is intertidal, while the Ghost lives above the high tide mark.

Part III Substrate Size

9. Fine mud for Fiddler since mud is found in the salt marshes. Medium sand for Ghost as this is the type found on the upper beach.
10. **Ghost** - larger burrow, more varied.
    Fiddler - fairly constant size and shape; smaller burrow; plugs up burrow in very wet substrate; sand or mud balls around entrance to burrow.
12. **Ghost** - light clear color, skittish quick behavior and nocturnal.
    Fiddler - one oversized claw, as if holding a fiddle.
13. Dancing activity in both crabs. Fiddler waves oversized claw.
14. See responses above.

Discussion

This is an excellent activity to study animal behavior; however, the student must be patient and let the crabs "do their own thing." Students should have success with the activity and should see differences between the Ghost crab and Fiddler crab.

Evaluation

Many of the students' responses should be the same. Controlling variables such as light, moisture and substrate size should not prove to be too difficult. In Part III, answers to question 13 will vary depending upon the students' patience.

Follow-Up

- Use candle wax or plaster of paris to make a mold of the Ghost and Fiddler crab burrows and compare the internal structures, such as depth, angle, width, number of branches, etc.
- Observe the formation of sand or mud pellets as a result of a Fiddler's burrowing and feeding activity.
- Investigate sexual dimorphism in Fiddler crabs.
- Use **Emerita** (mole crabs) or **Donax** (Butler Fly shells) to compare the time it takes for the animals to burrow to the bottom of a glass finger bowl filled with substrates of various sizes. Cover the substrate with 1 cm of seawater for this activity. Do several runs for each species and average the time for each particular size.

The Effects of Light, Oxygen and Temperature on the Hatching of Brine Shrimp

Level: 7-12

Pre-Lab

Concept

- Environmental variables and their effects on brine shrimp.

Suggested Prerequisite Skills

- Student must be able to follow directions.

Student Performance Objective

- Given brine shrimp, the student will determine the optimum conditions necessary for life by counting the number of live shrimp in various jars and comparing the results.

Materials, Times, Cautions

Materials

- Six wide mouth quart jars
- Pipette or dip net
- Brown paper bags or black construction paper
- Labels
- Non-iodized salt
- Air hose or stone and pump
- Dried yeast
- Aged tap water
- Salad oil
- Refrigerator

Time

This activity requires 14 days to complete.

Cautions

It will be essential to insure that no contamination occurs. There must be a specific pipette or dip net for each jar. It is suggested that these have a readable label attached that is color coded to match the jar. To put the air pump into the refrigerator, merely put it on the shelf, run the cord out the door to an extension cord and shut the door. The gasket will take care of this.

The Effects of Light, Oxygen and Temperature on the Hatching of Brine Shrimp Student Lab

General Information

You will be studying the effects of combinations of oxygen, light and temperature on the hatching and growth of brine shrimp. Just as it takes more than food and fresh air to promote the best development in you, so is it in brine shrimp. At times, some of these things have a synergistic effect. This will be one of the things that you will check.

Objective

- To determine the optimum conditions for brine shrimp life.

Materials

- Six wide mouth quart jars
- Brown paper bags or black construction paper
- Labels
- Non-iodized salt
- Air hose or stone and pump
- Dried yeast
- Aged tap water
- Salad oil
- Refrigerator
- Pipette
- Dip net
- Eyedropper

Processes **Student Discovery Activity**

Communicating 1. Six wide mouth quart jars and individual pipettes or dip nets should be labeled as follows:
   a. Warm, Light, Air
   b. Warm, Light, No Air
   c. Warm, Dark, Air
   d. Warm, Dark, No Air
   e. Cold, Dark, Air
   f. Cold, Dark, No Air

Measuring 2. Pour tap water that has been aged 24 hours into each jar and add 2 teaspoons of salt to each and mix.

Measuring 3. Add 20 shrimp to each jar. Be sure to count these accurately.

4. Do the following:
   a. Place Warm, Light, Air jar in a warm, lighted place. Put in air hose or air stone and leave uncovered.

b. Put Warm, Light, No Air jar in a warm, lighted place and add 2 tablespoons of salad oil to the top of the water. Do not use an air stone or hose.

c. Put Warm, Dark, Air jar in a warm, dark place and wrap it in black construction paper. Put in an air stone or hose.

d. Also wrap Warm, Dark, No Air jar in black paper, but add 2 tablespoons of salad oil to the top of the water and do not use an air stone or hose.

e. Put Cold, Dark, Air jar in a brown paper sack (or wrap in black paper), add an air hose or stone and place in refrigerator.

f. Also put Cold, Dark, No Air jar in a paper sack (or black paper), but add 2 tablespoons of salad oil and place in refrigerator without air hose or stone.

Observing

5. Count the number of live shrimp each day for about two weeks and record the answer on the data sheet. Remember to use the same dip net or pipette with each jar each day.
6. Feed the shrimp one piece of dried yeast per jar daily. You may wish to make a suspension of the yeast (1/2 teaspoon of yeast to 2 tablespoons water) and look at it under a microscope.
7. Data for Comparison of Temperature, Light and Oxygen Synergistic Experiments

NUMBER OF SHRIMP ALIVE ON:	WARM, LIGHT, AIR JAR	WARM, LIGHT, NO AIR JAR	WARM, DARK, AIR JAR	WARM, DARK, NO AIR JAR	COLD, DARK, AIR JAR	COLD, DARK, NO AIR JAR
DAY 1						
DAY 2						
DAY 3						
DAY 4						
DAY 5						
DAY 6						
DAY 7						
DAY 8						
DAY 9						
DAY 10						
DAY 11						
DAY 12						
DAY 13						
DAY 14						

Observing
Inferring

8. Which jar had the most shrimp alive at Day 3 and at Day 14?
9. Why do you think the jars listed in question 8 had optimum conditions for shrimp life?

Observing	10.	Which jar had the fewest live shrimp?
Inferring	11.	Why do you think this jar had the fewest?
Inferring	12.	What was the most severely limiting factor in this jar?
Communicating	13.	Rank the jars from highest to lowest according to the number of live shrimp. Place a check in the right column.

Jar	High	Low
1		
2		
3		
4		
5		
6		

Inferring	14.	What was the most limiting factor in the six jars?
Applying	15.	How would this limit you?
Applying	16.	Considering food, water, exercise and oxygen, which one can you survive the longest without?
Applying	17.	Which can you survive the shortest time without?
Communicating	18.	Draw a picture of yeast.
Comparing	19.	Compare the yeast size to the size of the shrimp.
Communicating	20.	Draw pictures of the following: shrimp egg, nauphilus, young shrimp, mature shrimp.
Designing an investigation	21.	Conduct further experiments by using other materials, such as one teaspoon of sugar, flour or other substances on brine shrimp.

The Effects of Light, Oxygen and Temperature on the Hatching of Brine Shrimp Post-Lab

Possible Answers to Questions

8. Answers will vary.
9. Answers will depend on responses to question 8.
10. Probably the no oxygen jar.
11. Animals must have oxygen to survive.
12. Answers will vary.
13. Jar 1--high; Jar 2--low; Jar 3--high; Jar 4--low; Jar 5--low; Jar 6--low.
14. Oxygen.
15. I would die in a very short time.
16. Exercise.
17. Oxygen
19. Shrimp should be larger.

Discussion

- Ask students to share their responses and continue the discussion on how light, oxygen and temperature are important for survival.

Evaluation

- Allow time to observe and record information on the brine shrimp.
- Discuss the differences that occur even though students followed the same procedure.

Follow-Up

- The Salt Factor in Raising Brine Shrimp activity.
- The Baby Shrimp Nursery activity.
- The Culturing of Brine Shrimp Larvae activity.

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Crusty Molts

Level: 7-12

Pre-Lab

Concept

- Temperature has an effect on all living organisms

Suggested Prerequisite Skills

Students should be familiar with the following: Habitat, environment, molting in crustaceans, pH of water, salinity, metabolism.

Students should have a working knowledge of the following: Thermometer, metric ruler, metric scale, drawing graphs, how to determine pH and salinity, and how to take scientific notes for daily observations.

Student Performance Objective

Given a crab or a crayfish, be able to determine the effects of temperature on the growth rate, molting rate, feeding habits and behavior of crabs in a marine environment or crayfish in fresh water.

Materials

- Two 20 gallon aquaria (one heated, one unheated)
- Six small crayfish approximately 1 cm in length (do not include claws)
- Six small blue crabs approximately 4-8 mm across the rostrum (see definitions)
- Two thermometers
- One metric scale
- Two metric rulers
- Graph paper for chart
- Camera (optional) to photograph growth stages
- Aquarium heater to maintain minimum temperature
- Aquarium heater to raise temperature
- Food supply (bits of dried shrimp, frozen brine, blue crab-shrimp, beef heart, kidney, etc.)
- Crayfish — **Elodea** or **Ancharis** plants, shrimp pellets (can be ordered from a supply house or can be caught in a minnow seine in a bay or estuary. If a crayfish farm is available, this would be ideal.)

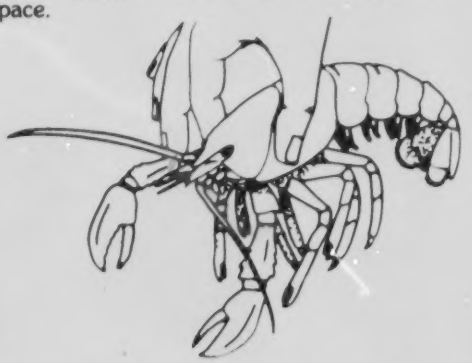
Time

Approximately 20 minutes per day for 6 to 8 weeks. The ideal situation would be for students to come to the lab before or after school. It is important that the variables be minimized as much as possible.

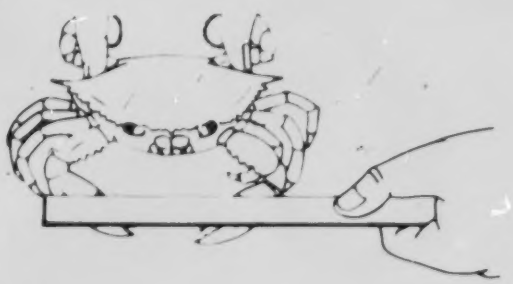
Cautions

The salinity and pH of the marine aquarium should be checked each day. The water level should be checked each day if you do not have a covered tank. A supply of non-chlorinated water should be kept on hand to replace the water lost through evaporation. The pH can be determined by using pH paper with a 3-11 range. The pH should be slightly basic, or 8.0 to 8.3. If it becomes acid, or below 7.0, add a slight amount of bicarbonate of soda (baking soda). The salinity should be 24 ‰ to 27 ‰.

Crayfish can be picked up with the thumb and forefinger. Place the thumb and forefinger just posterior to the chelipeds, on each side of the cephalothorax or carapace.



To pick up a blue crab, hold the anterior section (chelipeds) down with a ruler, stick or foot. Place the thumb and forefinger on the lateral side of the fifth pair of legs (swimming legs). This is posterior to the carapace. Remember small crabs can inflict injury as easily as a large crab.

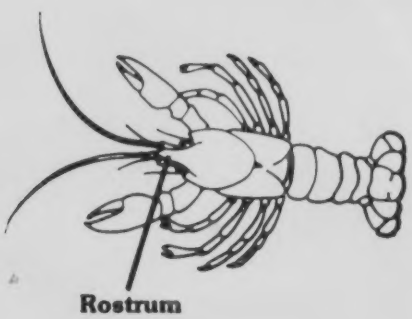


Definition of Terms

Specific gravity — The ratio of the density of a substance to the density of a substance (as pure water) taken as a standard when both densities are obtained by weighing in air.

Hydrometer — A floating instrument for determining specific gravities of liquids.

Salinity	Amount of dissolved salts in water, usually expressed in parts per thousand (‰); e.g., the number of grams of salt in 1,000 ml of water is the salinity, 35g/1000ml = 35 ‰.
Metabolism	The total of all the chemical reactions going on in a living cell and of all the energy changes accompanying them.
Olfactory receptors	Nerve endings that pertain to the sense of smell.
Environment	The complex of climatic, soil and biotic factors that act upon an organism or an ecological community and ultimately determine its form and survival.
Habitat	The place or type of site where a plant or animal naturally lives and grows.
Molt	To shed hair, feathers, shell, horns or an outer layer periodically.
Rostrum	The antenorly projecting beak, as in the crayfish.



Crusty Molts
Student Lab

General Information

The water temperature in our bays, estuaries and inland marshes varies greatly during the year. Will this variance affect the growth of edible crustaceans that inhabit these waters? This investigation will parallel nature as much as possible to show how temperature changes affect the growth (molting), feeding and behavior cycle of the blue crab and/or the crayfish.

Objective

- To investigate how temperature affects the physiological processes of crustaceans.

Materials

- Two 20 gallon aquaria; label one tank A — heated; and one tank B — unheated;
- Six small crayfish (if using fresh water)
- Six small blue crabs (if using saltwater)
- Two aquarium heaters
- Two thermometers to determine water temperature
- Two metric rulers to measure growth
- One metric scale to weigh unused food
- pH paper
- Hydrometer to measure salinity of saltwater (not needed for fresh water)
- Food supply (depends on animal used)
- Graph paper to record growth rates
- Scientific notebook for daily observations

Processes	Student Discovery Activity
	1. If you decide to use the **blue crab,** fill two 20 gallon aquaria with water from a bay or an ocean mix.
Measuring	2. Label the aquaria A or B.
	3. If you decide to use the **crayfish,** fill two 20 gallon aquaria with unpolluted ditch or pond water.
Measuring	4. Aerate the water in both aquaria for 24 hours before adding **three** animals (approximately 3 cm in length) to each aquarium. **Note:** Blue crabs will do well if the salinity is maintained between 18 to 26 ‰.
Measuring	5. Heat the water in aquarium A to 23°C (±1°) and maintain it.
Observing Controlling Variables	6. Maintain aquarium B between 10°C and 15°C. Place a thermostat in aquarium B and hold the temperature at a minimum of 10°C.
Communicating	7. Keep an accurate record of the amount of food placed in each aquarium.
	8. Shrimp pellets serve as an excellent food source.
Measuring	9. Animals should be fed on Monday, Wednesday and Friday. If any food remains after two hours, it should be removed, dried and then weighed.

Observing	10.	Observe the animals in each aquarium for **five** minutes each day.
Communicating	11.	Keep an accurate record of the behavior exhibited by each animal. Write down everything in detail, regardless of how repetitious it appears to be.
Observing	12.	Compare the animals in both aquarium. What differences in movement do you notice?
Observing	13.	What differences in feeding do you notice?
Observing Inferring	14.	Do animals locate food faster in one aquarium than in the other? Why?
Observing	15.	How frequent does molting occur?
Measuring	16.	Measure each animal after the molting has taken place.
Interpreting data	17.	After the molt, are there any differences in the time span between molts?
Interpreting data	18.	After the molting phase is there any difference in the size of the animal?
Interpreting data	19.	Does there appear to be any difference in metabolism between animals?
Inferring	20.	How does a crab or crayfish molt?
Predicting	21.	If there is more than one crab or crayfish in an aquarium, what do you think will happen to the one that molts?
	22.	Remove organisms from aquaria A and B and return them to their original aquarium.

Crusty Molts
Post-Lab

Possible Answers to Questions

12. The animals in aquarium A should move more and should be a little quicker. Students should observe crabs walking sideways and swimming with their fifth pair of legs. Crayfish can walk frontwards or backwards, but can swim only with the flipping of the tail in one direction (backwards).
13. Difference should depend on the answer in question 12.
14. Active animals should eat more food. The animals in aquarium A should locate their food faster since the water molecules move more rapidly in the aquarium; chemicals will dissipate faster.
    Crustaceans adapt by using their olfactory receptors which are located in their antennae.
15. Answers will vary due to temperature differences, amount of food and other variables. Aquarium A animals should molt more often.
17. Answers will vary.
18. The animals in aquarium A should increase their size more after each molt.
19. The rate of metabolism for animals in aquarium A should be more than aquarium B because of the differences in activity. All the data should be interpreted to prove the difference in the metabolic rate.
20. In molting, the upper portion of the crab shell separates from the lower portion along the posterior region. The crab then backs out of the shell, leaving a few gills. The crab takes in water to stretch out to its new size; the new shell remains soft for 24 to 48 hours.
    A crayfish molts by bending its shell ventrally between the cephalothorax and abdomen and backing out through the dorsal side. It stretches its new shell by taking in water. The shell remains soft for a few hours.
21. In most cases, a crab molting with other crabs will be killed and eaten. This will not happen with crayfish.

Discussion

This investigation can be related to the growth rate of blue crabs along the Gulf of Mexico compared to that of blue crabs in or near Chesapeake Bay. In 1979 Sea World in San Diego was involved in growth research on the New England lobster.

Evaluation

In this investigation students studied an animal which normally is found at the bottom of bays, rivers, creeks or ponds. They should experience success in measuring, controlling variables, making inferences, interpreting data and predicting.

Follow-Up

- Determine whether the size of the aquarium inhibits the growth of crustaceans.
- Use a greater temperature range.
- Use different genera of crabs.

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How Salty Is It?

Level: 9-12

Pre-Lab

Concept

- Salinity and marine organisms

Facts

- Salinity has an effect on shrimp and oysters.
- Specific gravity is proportional to salinity at a given temperature.

Suggested Prerequisite Skills

- Students should know how to read a thermometer and hydrometer.
- Student should be able to take notes and make daily observations and interpolations.

Student Performance Objectives

- Given a density-salinity conversion chart at 15°C, the student will be able to read it.
- Given a true salinity chart corrected to 15°C, the student will be able to read it.

Materials, Times, Cautions

Materials (for groups of two)

- Three graduated cylinders (large enough diameter so hydrometer does not touch side)
- One hydrometer with thermometer attached
- Three water samples: 1 gram of salt in one; 3 grams of salt in second; 10 grams of salt in third

Optional materials*

- Bunsen burner
- Ring stand with ring or aquarium heater

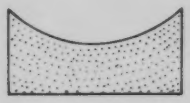
*Use only when investigating various water temperatures and a controlled amount of dissolved salts in solution.

Time

This investigation should take one class period.

Cautions

- A meniscus curve must be read correctly. A meniscus curve is the curved upper surface of a liquid column adjacent to the container's wall.



- The hydrometer must not stick to the side of the cylinder.
- Use a rule to make it easier to interpret Chart 2.

Definition of Terms

Specific gravity	The ratio of the density of a substance to the density of a substance taken as a standard when both densities are obtained by weighing them in air.
Hydrometer	A floating instrument for determining specific gravities of liquids.
Salinity	Amount of dissolved salts in water, usually expressed in parts per thousand (o/oo) e.g. the number of grams of salt in 1,000 ml of water is the salinity 35g/1000ml=35 o/oo.

How Salty Is It?
Student Lab

General Information

The hydrometer is a simple, inexpensive instrument used in science classes to determine the specific gravity of various liquids. In this activity, it will be used to determine the specific gravity of samples of seawater.

Objective

- To use a hydrometer to determine the salinity of several samples of seawater.

Materials

- One hydrometer with thermometer
- One set of comparison charts
- Three graduated cylinders with unknown water samples

Processes

Student Discovery Activity

This activity should be done by groups of two.

Observing
1. Read Charts 1 and 2. Notice Chart 1 provides the salinity for a specific gravity reading at 15°C, while Chart 2 provides a corrected salinity reading at 15°C if there is a change in temperature.

Observing
2. Place a hydrometer in cylinder A (1 g of salt). Make sure the hydrometer does not touch the side of the cylinder.
3. Note: Your eye should be placed at water level.
4. Record the number at the bottom of the meniscus and the temperature of the water on Data Sheet Chart.

Data Sheet Chart

Sample	Specific Gravity	Salinity	Temperature	Corrected Salinity @ 15°C
A				
B				
C				
Example	1.024	32.4	20°C	30.8

Observing
5. Repeat the same procedure for cylinders B (3 g of salt) and C (10 g of salt).

Observing
6. Use Chart 1 to look up the salinity for the corresponding density at 15°C. For example, if you have a specific gravity of 1.024, the chart contains a salinity of 32.4 o/oo.

Measuring 7. If the temperature is not 15°C; then Chart 2 should be used. Find 20°C in the temperature column; then find the 32 o/oo and 33 o/oo reading at the top of the chart.

Interpreting data 8. Follow across horizontally along the 20°C line until this line intersects with the 32 o/oo line (30.4) and 33 o/oo (31.4). The difference between 32 o/oo and 33 o/oo is 1. The original reading was 32.4 o/oo, which means that .4 should be added to the corrected salinity (30.4) which would provide a final corrected reading of 30.8 o/oo for a specific gravity reading of 1.024 at 20°C.

Observing 9. What is the reading on a hydrometer for distilled water?

Interpreting data 10. Which water sample has the most dissolved salt?

Inferrring 11. Why is knowing the temperature important?

Communicating 12. What is the salinity of the following at 15°C?

Complete the chart below.

Density	Salinity	Temperature	Salinity
1.0038	o/oo	18°C	o/oo
1.0153	o/oo	10°C	o/oo
1.0260	o/oo	12°C	o/oo
1.0291	o/oo	22°C	o/oo

Chart 1. Corresponding Densities and Salinities

(Density at 15° C -- Salinity in parts per 1000)

Density	Salinity	Density	Salinity	Density	Salinity	Density	Salinity	Density	Salinity	Density	Salinity
0.9991	0.0	1.0046	7.1	1.0101	14.2	1.0156	21.4	1.0211	28.6	1.0266	35.8
0.9992	0.0	1.0047	7.2	1.0102	14.4	1.0157	21.6	1.0212	28.8	1.0267	35.9
0.9993	0.2	1.0048	7.3	1.0103	14.5	1.0158	21.7	1.0213	28.9	1.0268	36.0
0.9994	0.3	1.0049	7.5	1.0104	14.6	1.0159	21.8	1.0214	29.0	1.0269	36.2
0.9995	0.4	1.0050	7.6	1.0105	14.8	1.0160	22.0	1.0215	29.1	1.0270	36.3
0.9996	0.6	1.0051	7.7	1.0106	14.9	1.0161	22.1	1.0216	29.3	1.0271	36.4
0.9997	0.7	1.0052	7.9	1.0107	15.0	1.0162	22.2	1.0217	29.4	1.0272	36.6
0.9998	0.8	1.0053	8.0	1.0108	15.2	1.0163	22.4	1.0218	29.5	1.0273	36.7
0.9999	0.9	1.0054	8.1	1.0109	15.3	1.0164	22.5	1.0219	29.7	1.0274	36.8
1.0000	1.1	1.0055	8.2	1.0110	15.4	1.0165	22.6	1.0220	29.8	1.0275	37.0
1.0001	1.2	1.0056	8.4	1.0111	15.6	1.0166	22.7	1.0221	29.9	1.0276	37.1
1.0002	1.3	1.0057	8.5	1.0112	15.7	1.0167	22.9	1.0222	30.1	1.0277	37.2
1.0003	1.5	1.0058	8.6	1.0113	15.8	1.0168	23.0	1.0223	30.2	1.0278	37.3
1.0004	1.6	1.0059	8.8	1.0114	16.0	1.0169	23.1	1.0224	30.3	1.0279	37.5
1.0005	1.7	1.0060	8.9	1.0115	16.1	1.0170	23.3	1.0225	30.4	1.0280	37.6
1.0006	1.9	1.0061	9.0	1.0116	16.2	1.0171	23.4	1.0226	30.6	1.0281	37.7
1.0007	2.0	1.0062	9.2	1.0117	16.3	1.0172	23.5	1.0227	30.7	1.0282	37.9
1.0008	2.1	1.0063	9.3	1.0118	16.5	1.0173	23.7	1.0228	30.8	1.0283	38.0
1.0009	2.2	1.0064	9.4	1.0119	16.6	1.0174	23.8	1.0229	31.0	1.0284	38.1
1.0010	2.4	1.0065	9.6	1.0120	16.7	1.0175	23.9	1.0230	31.1	1.0285	38.2
1.0011	2.5	1.0066	9.7	1.0121	16.9	1.0176	24.1	1.0231	31.2	1.0286	38.4
1.0012	2.6	1.0067	9.8	1.0122	17.0	1.0177	24.2	1.0232	31.4	1.0287	38.5
1.0013	2.8	1.0068	9.9	1.0123	17.1	1.0178	24.3	1.0233	31.5	1.0288	38.6
1.0014	2.9	1.0069	10.1	1.0124	17.2	1.0179	24.4	1.0234	31.6	1.0289	38.8
1.0015	3.0	1.0070	10.2	1.0125	17.4	1.0180	24.6	1.0235	31.8	1.0290	38.9
1.0016	3.2	1.0071	10.3	1.0126	17.5	1.0181	24.7	1.0236	31.9	1.0291	39.0
1.0017	3.3	1.0072	10.5	1.0127	17.7	1.0182	24.8	1.0237	32.0	1.0292	39.2
1.0018	3.4	1.0073	10.6	1.0128	17.8	1.0183	25.0	1.0238	32.1	1.0293	39.3
1.0019	3.5	1.0074	10.7	1.0129	17.9	1.0184	25.1	1.0239	32.3	1.0294	39.4
1.0020	3.7	1.0075	10.8	1.0130	18.0	1.0185	25.2	1.0240	32.4	1.0295	39.6
1.0021	3.8	1.0076	11.0	1.0131	18.2	1.0186	25.4	1.0241	32.5	1.0296	39.7
1.0022	3.9	1.0077	11.1	1.0132	18.3	1.0187	25.5	1.0242	32.7	1.0297	39.8
1.0023	4.1	1.0078	11.2	1.0133	18.4	1.0188	25.6	1.0243	32.8	1.0298	39.9
1.0024	4.2	1.0079	11.4	1.0134	18.6	1.0189	25.8	1.0244	32.9	1.0299	40.1
1.0025	4.3	1.0080	11.5	1.0135	18.7	1.0190	25.9	1.0245	33.1	1.0300	40.2
1.0026	4.5	1.0081	11.6	1.0136	18.8	1.0191	26.0	1.0246	33.2	1.0301	40.3
1.0027	4.6	1.0082	11.8	1.0137	19.0	1.0192	26.1	1.0247	33.3	1.0302	40.4
1.0028	4.7	1.0083	11.9	1.0138	19.1	1.0193	26.3	1.0248	33.5	1.0303	40.6
1.0029	4.8	1.0084	12.0	1.0139	19.2	1.0194	26.4	1.0249	33.6	1.0304	40.7
1.0030	5.0	1.0085	12.2	1.0140	19.3	1.0195	26.5	1.0250	33.7	1.0305	40.8
1.0031	5.1	1.0086	12.3	1.0141	19.5	1.0196	26.7	1.0251	33.8	1.0306	41.0
1.0032	5.2	1.0087	12.4	1.0142	19.6	1.0197	26.8	1.0252	34.0	1.0307	41.1
1.0033	5.4	1.0088	12.6	1.0143	19.7	1.0198	26.9	1.0253	34.1	1.0308	41.2
1.0034	5.5	1.0089	12.7	1.0144	19.9	1.0199	27.1	1.0254	34.2	1.0309	41.4
1.0035	5.6	1.0090	12.8	1.0145	20.0	1.0200	27.2	1.0255	34.4	1.0310	41.5
1.0036	5.8	1.0091	12.9	1.0146	20.1	1.0201	27.3	1.0256	34.5	1.0311	41.6
1.0037	5.9	1.0092	13.1	1.0147	20.3	1.0202	27.5	1.0257	34.6	1.0312	41.7
1.0038	6.0	1.0093	13.2	1.0148	20.4	1.0203	27.6	1.0258	34.8	1.0313	41.9
1.0039	6.2	1.0094	13.3	1.0149	20.5	1.0204	27.7	1.0259	34.9	1.0314	42.0
1.0040	6.3	1.0095	13.5	1.0150	20.6	1.0205	27.8	1.0260	35.0	1.0315	42.1
1.0041	6.4	1.0096	13.6	1.0151	20.8	1.0206	28.0	1.0261	35.1	1.0316	42.3
1.0042	6.6	1.0097	13.7	1.0152	20.9	1.0207	28.1	1.0262	35.3	1.0317	42.4
1.0043	6.7	1.0098	13.9	1.0153	21.0	1.0208	28.2	1.0263	35.4	1.0318	42.5
1.0044	6.8	1.0099	14.0	1.0154	21.2	1.0209	28.4	1.0264	35.5	1.0319	42.7
1.0045	6.9	1.0100	14.1	1.0155	21.3	1.0210	28.5	1.0265	35.7	1.0320	42.8

Chart 2
True Salinities for Sea Water - Corrected to 15° C

Temp of Water in Jar	CORRECTED OR TRUE SALINITIES											
	14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0	22.0	23.0	24.0	25.0
	OBSERVED SALINITIES											
-2° C	15.5	16.5	17.6	18.6	19.7	20.8	21.8	22.9	24.1	25.1	26.2	27.2
0	15.7	16.7	17.7	18.8	19.9	21.0	22.1	23.1	24.2	25.2	26.3	27.3
2	15.7	16.7	17.8	18.8	19.9	20.9	22.0	23.0	24.0	25.1	26.1	27.2
4	15.7	16.7	17.7	18.8	19.9	20.8	21.8	22.9	23.9	25.0	26.0	27.0
6	15.5	16.5	17.5	18.6	19.6	20.6	21.7	22.7	23.7	24.7	25.8	26.8
8	15.3	16.3	17.3	18.3	19.4	20.4	21.4	22.4	23.5	24.5	25.5	26.5
10	15.0	16.0	17.0	18.0	19.0	20.0	21.0	22.1	23.1	24.1	25.1	26.1
12	14.7	15.7	16.7	17.7	18.7	19.7	20.7	21.7	22.7	23.7	24.7	25.7
14	14.2	15.2	16.2	17.2	18.2	19.2	20.2	21.2	22.2	23.2	24.2	25.2
15	14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0	22.0	23.0	24.0	25.0
16	13.8	14.8	15.8	16.8	17.8	18.7	19.7	20.7	21.7	22.7	23.7	24.7
18	13.2	14.2	15.2	16.2	17.2	18.2	19.2	20.2	21.2	22.2	23.1	24.1
20	12.6	13.6	14.6	15.6	16.6	17.6	18.6	19.6	20.6	21.6	22.5	23.5
22	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	19.9	20.9	21.9	22.9
24	11.3	12.3	13.3	14.3	15.3	16.3	17.3	18.3	19.2	20.2	21.2	22.2
26	10.6	11.6	12.6	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.4	21.4
28	9.8	10.8	11.8	12.7	13.7	14.7	15.7	16.7	17.7	18.7	19.6	20.6
30	9.0	10.0	11.0	11.9	12.9	13.9	14.9	15.8	16.8	17.8	18.7	19.7

Temp of Water in Jar	CORRECTED OR TRUE SALINITIES											
	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0
	OBSERVED SALINITIES												
-2° C	1.7	2.8	3.9	5.0	6.1	7.2	8.2	9.2	10.3	11.3	12.4	13.4	14.4
0	1.8	2.9	4.0	5.1	6.2	7.3	8.3	9.4	10.4	11.5	12.6	13.6	14.6
2	1.8	2.9	4.0	5.1	6.2	7.3	8.4	9.4	10.5	11.5	12.6	13.6	14.6
4	1.8	2.9	4.0	5.1	6.2	7.3	8.4	9.4	10.5	11.5	12.6	13.6	14.6
6	1.7	2.8	3.9	5.1	6.2	7.3	8.4	9.4	10.4	11.4	12.4	13.5	14.5
8	1.7	2.8	3.9	5.0	6.1	7.1	8.2	9.2	10.2	11.2	12.2	13.3	14.3
10	1.6	2.7	3.7	4.8	5.8	6.8	7.9	8.9	9.9	11.0	12.0	13.0	14.0
12	1.4	2.4	3.4	4.5	5.6	6.6	7.6	8.6	9.6	10.6	11.6	12.6	13.6
14	1.1	2.1	3.1	4.1	5.2	6.2	7.2	8.2	9.2	10.2	11.2	12.2	13.2
15	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0
16	0.8	1.8	2.8	3.8	4.8	5.8	6.8	7.8	8.8	9.8	10.8	11.8	12.8
18	0.4	1.4	2.3	3.3	4.3	5.3	6.2	7.2	8.2	9.2	10.2	11.2	12.2
20		0.9	1.8	2.8	3.8	4.8	5.7	6.7	7.7	8.7	9.7	10.6	11.6
22		0.4	1.3	2.3	3.3	4.2	5.1	6.1	7.1	8.1	9.1	10.0	11.0
24			0.8	1.8	2.7	3.6	4.5	5.5	6.5	7.4	8.4	9.4	10.4
26			0.3	1.1	2.1	3.0	3.9	4.8	5.8	6.7	7.7	8.7	9.7
28				0.3	1.2	2.2	3.1	4.1	5.0	6.0	6.9	7.9	8.9
30					0.3	1.3	2.3	3.3	4.2	5.2	6.1	7.1	8.1

Chart 2 continued
True Salinities for Sea Water - Corrected to 15° C

Temp of Water in Jar	CORRECTED OR TRUE SALINITIES											
	26.0	27.0	28.0	29.0	30.0	31.0	32.0	33.0	34.0	35.0	36.0	37.0
	OBSERVED SALINITIES											
-2° C	28.3	29.4	30.4	31.5	32.5	33.6	34.6	35.7	36.7	37.8	38.9	40.0
0	28.3	29.4	30.4	31.5	32.5	33.6	34.6	35.6	36.7	37.7	38.8	39.8
2	28.2	29.3	30.3	31.4	32.4	33.4	34.5	35.5	36.6	37.6	38.7	39.7
4	28.1	29.1	30.1	31.2	32.2	33.2	34.2	35.3	36.3	37.4	38.4	39.4
6	27.8	28.9	29.9	30.9	31.9	33.0	34.0	35.0	36.0	37.1	38.1	39.1
8	27.5	28.5	29.6	30.6	31.6	32.6	33.6	34.6	35.7	36.7	37.7	38.7
10	27.2	28.2	29.2	30.2	31.2	32.2	33.2	34.2	35.3	36.3	37.3	38.3
12	26.7	27.7	28.8	29.8	30.8	31.8	32.8	33.8	34.8	35.8	36.8	37.8
14	26.2	27.2	28.2	29.2	30.2	31.2	32.3	33.3	34.3	35.3	36.3	37.3
15	26.0	27.0	28.0	29.0	30.0	31.0	32.0	33.0	34.0	35.0	36.0	37.0
16	25.7	26.7	27.7	28.7	29.7	30.7	31.7	32.7	33.7	34.7	35.7	36.7
18	25.1	26.1	27.1	28.1	29.1	30.1	31.1	32.1	33.1	34.1	35.1	36.1
20	24.5	25.5	26.5	27.5	28.5	29.4	30.4	31.4	32.4	33.4	34.4	35.4
22	23.8	24.8	25.8	26.8	27.8	28.7	29.7	30.7	31.7	32.7	33.7	34.7
24	23.1	24.1	25.1	26.1	27.1	28.1	29.0	30.0	31.0	32.0	33.0	34.0
26	22.4	23.4	24.4	25.4	26.3	27.3	28.2	29.2	30.2	31.2	32.2	33.1
28	21.6	22.6	23.5	24.5	25.5	26.5	27.4	28.4	29.4	30.4	31.4	32.3
30	20.7	21.7	22.6	23.6	24.6	25.6	26.5	27.5	28.5	29.5	30.4	31.4

Example: When the observed reading on the hydrometer is 9.7 o/oo and the water temperature reading on the thermometer is 20° C, locate 20° C line on the left hand column, (temperature of water in jar). Follow across horizontally until coming to observed reading (9.7 o/oo). At the top of this column the corrected, or true salinity reading will be found; which in this case is 11.0 o/oo. Observed salinities falling between those shown on the chart may easily be interpolated.

How Salty Is It?
Post-Lab

Possible Answers to Questions

9. 0.9991 or 1.000 on a hydrometer.
10. The sample with the highest specific gravity.
11. Answer will vary. However, the density of water increases as its temperature goes down and decreases as its temperature goes up.
12.

Density	Salinity	Temperature	Salinity
1.0038	6.0	18°C	5.3
1.0153	21.0	10°C	22.1
1.0260	35.0	12°C	35.8
1.0291	39.0	22°C	36.7

Discussion

The information gained by knowing how to determine salanites may be the difference between life and death of your organisms. Many marine organisms cannot adjust to a salinity change of more than a few parts per thousand.

Evaluation

This method of determining salinities is inexpensive and fairly accurate. This is an activity where the skill of interpolation is taught.

Follow-Up

This activity will be repeated at various intervals throughout these marine science experiences.

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Link Behavior

Level: 9-12

Pre-Lab

Concept

- Motile or sessile polychaetes.

Facts

- Not all polychaetes are motile; some are sessile tube-dwellers.
- Tube worms withdraw into their tubes when shadows are cast on the animals or when they are disturbed by vibrations (tapping on the side of the aquarium).
- Tube-dwelling polychaetes are filter-feeders, trapping plankton in the mucus-covered radioles of the funnel-shaped crown. Cilia on the radioles generate water currents used to trap the food particles.
- The sessile tube worms generally differ from more motile polychaetes in that the head region is modified for filter-feeding and the number and/or size of the parapodia is reduced.

Suggested Prerequisite Skills

- Student should be familiar with the general anatomy of polychaetes.
- Student should know basic dissecting skills.
- Student should be able to use the dissecting microscope.

Student Performance Objectives

- Given a tubeworm, the student will describe the general response the organism has to light and vibrations.
- Given a tubeworm, the student will describe its feeding behavior.
- Given sessile and motile polychaetes, the student will be able to compare their anatomy.

Materials, Time, Cautions

Materials (per group of students)

- Brine shrimp
- Dissecting kit
- Dissecting microscope or magnifying glass
- One live polychaete worm
- One preserved **Nereis**
- One preserved **Sabella**
- Pipette or eye dropper

Note: Preserved specimens may be obtained from Carolina Biological Supply Company or some other supply house.

Materials (for class use)

- Aquarium
- Aerator

Time

This laboratory experience will require one full class period, 55 minutes in length.

Cautions

- If your specimens of tube-dwelling polychaetes are too small for successful dissection, you may want students to look at the preserved plume worms **(Sabella)**. Preserved specimens of **Nereis** would be nice for comparison.
- A few living clam worms **(Neanthus)** or some other motile species would provide students with a better comparison of the activity levels of motile and sessile polychaetes.
- Don't forget to rinse brine shrimp and put them in regular strength seawater before pipetting into container with tube worms. You may want to transfer tubeworms into large beakers so more students can view them.

Definition of Terms

Parapodia	Paired lateral paddlelike locomotion, and sometimes respiratory, appendages of polychaetes.
Radioles	Stiff food gathering tentacles of some polychaetes, generally a respiratory organ as well; forms the funnel-shaped **crown**.

Link Behavior
Student Lab

General Information

Not all species of polychaete worms are motile like the clam worm, **Nereis** (Figure 1). Many are sessile tube-dwellers. Depending on the species, tubes may be made of hardened parchment like mucus, calcium carbonate (lime), or cemented sand grains or bits of shell.

Tube worms generally have two groups of tentacles (Radioles) which form a funnel-shaped crown at the anterior end (Figure 2). The crown aids in filter-feeding and respiration. Cilia on the radioles create water currents to trap tiny organisms (plankton) on the sticky mucus-covered crown. Ciliary action carries the food-laden mucus along grooves to the mouth. Food particles will be strained from the swallowed mucus. The mucus is absorbed and recycled.

Figure 1. **Nereis**

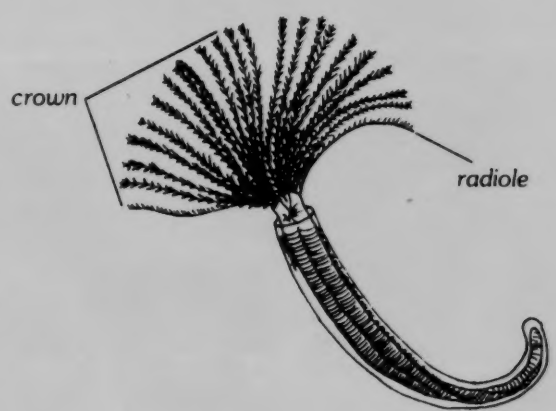

Figure 2. **Sabella**

Objectives

- To describe a tube worm's general response to light and vibrations.
- To describe the feeding behavior of tube worms.
- To compare the basic anatomy of sessile and motile polychaetes.

Materials

- Aerator
- Aquarium
- Brine shrimp
- Large beaker

- Dissecting kit
- Dissecting microscope or magnifying glass
- Live polychaete worms
- Preserved polychaete worms, **Neremis** and **Sabella**

Processes	Student Discovery Activity
Observing	1. If you pass your hand over the top of an aquarium and the hand casts a shadow on the animal, what happens to the fully extended tube worm?
Observing	2. If you tap the side of an aquarium, what happens to a fully extended tube worm?
Predicting	3. What do you think will happen when you add dead brine shrimp to the water in an aquarium containing a fully extended feeding crown of a tube worm?
Observing	4. What did happen?
Inferring	5. Do you think anything would happen if you changed **dead** brine shrimp for **live** brine shrimp in step 3?
Observing	6. What happened?
Communicating	7. Describe your observations on the feeding behavior of tube worm.
Comparing	8. Compare the external anatomy of a sand-burrowing, predatory polychaete such as **Nereis** and your sessile tube-dwelling polychaete.
Inferring	9. How is each suited to its particular life style?

Link Behavior
Post-Lab

Possible Answers to Questions

1. Withdraws, slowly emerges.
2. Withdraws, slowly emerges.
3. Answers will vary.
4. May or may not accept the offering.
5. Answers will vary.
6. May or may not show feeding behavior.
7. Brine shrimp become trapped in radioles, shrimp slowly swept to center of funnel, shrimp disappear into mouth.

Note: Disturbances may cause worms to abandon feeding behavior and withdraw into tube.

8 and 9. Sessile tube-dwelling polychaetes have head region modified for filter-feeding instead of jaws for actively catching prey. Generally the number and size of the parapodia is reduced in tube worms as they are no longer needed for locomotion. Respiratory function of parapodia has been assumed by the radioles as well.

Discussion

Responses to shadows and vibrations should be consistent. Feeding behavior may be variable, depending on hunger and other environmental disturbances.

Evaluation

- Like so many other organisms, different species of polychaetes are adapted to their own niches (environments and occupations). Cite specific examples of adaptations in polychaetes.
- Describe the feeding behaviors in polychaetes.
- Describe how tube worms respond to shadows and vibrations. How may such behavior be adaptive?

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Shining Light

Level: 9-12

Pre-Lab

Concept

- Living things and bioluminescence

Facts

- Bioluminescence is the production of light by living things.
- Many organisms are bioluminescent, including certain species of mushrooms, bacteria, coelenterates, mollusks, insects and fish.
- Although the chemicals involved are different all bioluminescent organisms combine **luciferins** with **oxygen** with the help of special enzymes called **luciferases** to form compounds which break down to form **light** instead of heat.
- **Photobacterium fischeri**, a bioluminescent decomposer, can be isolated from marine fish.

Suggested Prerequisite Skills

- Students must be familiar with the functions of enzymes and have some knowledge of bioluminescence.
- Students should be familiar with techniques in bacteriology.

Student Performance Objective

- Given the term bioluminescence, the student should describe it and give four examples.
- Given the terms luciferins, luciferases, oxygen and light, the student should develop a chemical reaction which will produce bioluminescence.
- Given a bioluminescent species of bacteria from marine fish, the student will isolate it.

Materials, Time, Caution

Materials (for group of students)

- 500 ml beaker
- Bunsen burner
- 500 ml Erlenmeyer flask
- Glass stirring rod
- 100 ml graduated cylinder
- Innoculating loop (or sterile cotton swab)
- Lab apron
- Three sterile petri dishes (20 x 100 mm)
- Ring stand, ring, wire screen
- Safety goggles
- Sterile cotton stopper
- Test tube
- Nutrient agar:
  250 ml sterile seawater (autoclaved)
  5.0 g peptone
  4.0 g powdered agar
  2.5 g glycerin (glycerol)

Note: Prepared powdered nutrient agar can be used as long as sterile seawater and glycerine also are added. Special Photobacterium agar can be purchased from Boreal Laboratories Ltd. or Carolina Biological Supply Company.

Materials (for class use)

- Autoclave (pressure cooker)
- Disinfectant
- Sponges
- Laboratory balance
- Tongs or potholders
- Fresh **unwashed** marine fish from the market, wrapped and refrigerated one to two days (you may want to get more to increase chances of success)

Note: Cultures of Photobacterium fishcheri can be obtained from Boreal Laboratories Ltd. or Carolina Biological Supply Company.

Time

One full laboratory period will be needed to prepare the media and streak the plates. Allow 5 to 10 minutes to check the plates each day. When you have positive results allow 15 to 30 minutes to complete the laboratory.

To shorten the time required, (a) prepare and autoclave the media in advance and let the students pour their own plates; and (b) pour autoclave media prior to class.

Caution

Be sure proper bacteriological procedures are followed. Students should wash desks with disinfectant before and after use. Disposable items should be soaked in disinfectant and/or autoclaved. All used petri dishes should be autoclaved before disposal.

Definition of Terms

Bioluminescence	Production of light by living organisms
Luciferins	Substance in bioluminescent organisms that produces light by combining with oxygen in the presence of luciferase.
Luciferase	Oxydizing enzymes which act with luciferin to produce light.
Generalized chemical reaction involved in bioluminescence	Luciferin + oxygen luciferase luciferin breakdown + **light** product

Shining Light
Student Lab

General Information

Have you ever walked along the beach at night and discovered that your footprints sparkled in the dark or that, when disturbed, the water flashed as though filled with hundreds of tiny blue fireflies? What you observed was the **bioluminescence** of certain species of bacteria or dinoflagellates. Bioluminescence is the production of light by living organisms--the same kind of reaction found in lightning bugs. Although the chemicals involved are different, all bioluminescent organisms combine certain chemicals (luciferins) with oxygen with the help of special enzymes (luciferases) to form compounds which release light instead of heat as they spontaneously break down.

Objectives

- To prepare an agar medium on which bacteria will grow.
- To describe what is meant by bioluminescence and be able to give examples.
- To write a chemical equation for bioluminescence.

Materials

- Autoclave
- Laboratory balance
- 500 ml beaker
- Bunsen burner
- Burner igniter
- 500 ml Erlenmeyer flask
- Glass stirring rod
- Graduated cylinder
- Lab apron
- Innoculating loop (or sterile cotton swab)
- Three sterile petri dishes (20 mm X 100 mm)
- Ring stand, ring, and wire screen
- Safety goggles
- Tongs or potholders
- Sterile cotton stopper
- Test tube
- One fresh, unwashed marine fish (wrapped and refrigerated 1-2 days)
- 250 ml sterile sea water
- 5.0 g peptone
- 4.0 g powdered agar
- 2.5 g glycerin

Processes

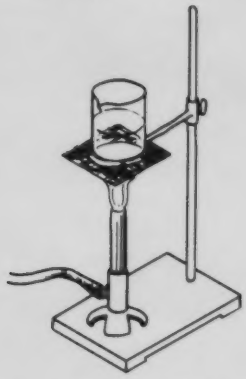
Student Discovery Activity

1. Wear safety goggles and lab apron while preparing agar.

2. Wash desk with disinfectant before and after use.
3. Follow your teacher's instructions for proper disposal of materials.
4. Remember: some of the bacteria you come in contact with may be harmful.

Preparing the agar medium

1. Set up the ringstand, ring, and wire screen as shown in the illustration.

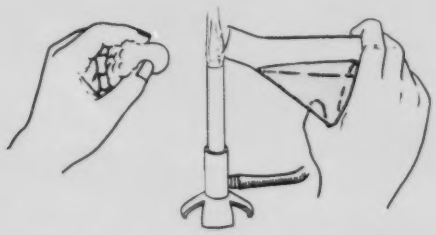


Measuring

2. Measure 250 ml of seawater in a 500 ml beaker. Bring the water to a boil and **shut off** the Bunsen burner.
3. **Slowly** add the peptone, glycerin, and agar powder, **stirring constantly**. Try not to strike the sides of the beaker with the stirring rod.

Observing

4. Let the medium cool slightly. Using some kind of **potholder**, carefully pour the liquid into the Erlenmeyer flask and plug with the cotton stopper. Autoclave (sterilize) the flask at 15 psi for 15 minutes.



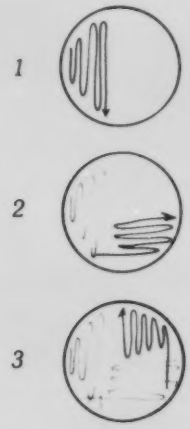
Measuring

5. Cover the petri dishes with about 5 mm of sterilized liquid. Lift the covers only enough to allow the liquid to enter and then recover immediately to avoid contamination. Allow the medium to solidify (about 15 minutes).

6. Sterilize your innoculating loop by holding it in the blue portion of the flame until the wire glows red. Let it cool for about 10 to 15 seconds and then scrape some slime from the scales of the fish.

Following directions

7. Streak one of the petri dishes with the slime as illustrated. Open the petri dish only wide enough to allow the loop to enter.
Note: Be careful not to contaminate yourself or anything else. Some of the bacteria may be harmful.



Flame and cool loop between 1 and 2, 2 and 3

8. Reflame the innoculating loop. Allow it to cool and streak the second petri dish. Resterilize the innoculating loop before setting it down.
9. Leave the third petri dish alone.
10. Incubate the dishes in a dark, cool place but do not refrigerate.

Observing

11. Examine dishes daily for bioluminescent colonies of bacteria. Using a sterile innoculating loop transfer any such colonies to a test tube of sterile seawater. **Resterilize** the loop before setting it down.
12. Go in a darkened room. Shake the test tube containing the luminescent bacteria.

Communicating

13. Record your observations on your paper.

Communicating Interpreting data

14. Explain what is meant by bioluminescence and give four examples of organisms which are bioluminescent.

Inferring	15.	How do you think bioluminescence may help organisms to survive?
Interpreting data	16.	What chemical reaction takes place in bioluminescence?
Communicating		Write your answer in an equation.
Predicting	17.	Since bioluminescent reactions are enzyme controlled, what effects might the following have on the rate of reaction (amount of light produced)? a) increasing temperature b) decreasing temperature c) pH
Designing an investigation	18.	It has been said that oxygen is necessary for the bioluminescent reaction to take place. Design an experiment which would try to show that this statement is true.
Hypothesizing	19.	Describe what results you might expect.

Shining Light
Post-Lab

Possible Answers to Questions

14. Bioluminescence is the production of light by living organisms; mushrooms, bacteria, coelenterates, squid, fireflies, deep sea fish.
15. No special value (this is a distinct possibility, especially for bacteria and dinoflagellates); frighten predators; provide fake target for predators; pattern for species recognition for mating or schooling (fish and fireflies); predators may match pattern of prey to fool them (deep sea fish); stake out territory (schooling fish); provide beacons or lures to aid in food capture (deep sea fish).
16. Luciferin + oxygen $\xrightarrow{\text{luciferase}}$ luciferin breakdown + oxygen product
17. Increasing temperature will increase rate and amount of light until enzyme is deactivated; lowering temperature will decrease rate and light (slows down molecules); too much pH change in either direction will slow down and eventually stop reaction as enzyme is deactivated.
18. A possible explanation follows: Put agar plates in oxygen-free atmosphere (chamber in which burning candle has removed oxygen); light should go out (should return when bacteria is placed back into oxygenated atmosphere).

Discussion

Discuss bioluminescence as an enzymatic reaction. Ask students to discuss any articles they have read on the subject.

Evaluation

- Refer to previously stated questions.

Follow-Up

- Have students try experiment on the necessity of oxygen.
- Have students report on bioluminescence in other organisms.
- Have students find out about phosphorescence and chemoluminescence.

References

Fleming, John N. (ed.) **Marine Science Project Cards.** New York: Center for Applied Research in Education, Inc., 1978.

Johnson, F.H. and Y. Haneder (eds.) **Bioluminescence in Progress.** Princeton University Press, Princeton, 1966.

McElroy, W.D. and B. Glass. **A Symposium on Life and Light.** Johns Hopkins Press, Baltimore, 1961.

Zahl, A. "Nature's Night Lights: Probing the Secrets of Bioluminescence." **National Geographic.** July, 1971.

The Beat of a Mussel

Level: 9-12

Pre-Lab

Concept

- The temperature of the environment determines the activity of some animals.

Facts

- Mollusks are poikilothermic animals.
- Poikilotherms do not maintain a constant body temperature. Their temperature varies with that of the surrounding environment.
- The rate of metabolism determines the body temperature.
- Heartbeat can be an indicator of metabolic rate. The body fluid (not red) will be pumped through arteries to the viscera and mantle.
- Heartbeat can be observed in the marine mollusk, **Modiolus demissus**, the horse mussel.

Prerequisite Skills

- Students should have a basic ability to do careful dissection.
- They should have an understanding of pelecypod anatomy.
- Students should be able to draw a line graph.

Objectives

- Given a pelecypod mollusk, **Modiolus demissus,** the student will dissect the organism, expose the heart, observe its contractions and record the heart beat.
- Given a pelecypod mollusk, the student will change the water temperature of the fluid surrounding the animal and observe and record its heart rate.

Materials and Times

Materials

- One dissected specimen of **Modiolus demissus**. (It is good to do this activity immediately following the activity on Pelecypod anatomy, using the dissected specimen.)
- Seawater at 8-10°C, 15-17°C, 20-23°C and 27-30°C.
- Small bowls to cover mussel with seawater.
- Stereo dissecting microscope
- Clock with a second hand
- Celsius thermometer

Time

If this exercise is used as a follow-up to the anatomy activity, it will require 15 to 20 minutes. At least 45 to 50 minutes will be required to dissect and expose the heart.

Definition of Terms

Poikilothermic — An organism whose body temperature varies with the temperature of its environment.

Homothermic — An organism which maintains a body temperature regardless of the temperature of its environment.

The Beat of a Mussel
Student Lab

General Information

Pelecypod mollusks are poikilothermic animals which do not maintain a constant body temperature, but rather change their temperature in response to the temperature of their surrounding environment.

The rate of metabolism determines the body temperature. (Why?).

Metabolism increases due to the temperature increase.

Heartbeat is an indicator of metabolic rate. Heartbeat in the horse mussel can be observed if you expose the pericardial cavity and flood the animal with seawater. By changing the temperature of this surrounding water, the effects on the heartbeat can be noted.

Objectives

- To observe the heart and count the heart contraction rate.
- To change the temperature of the water surrounding the animal and determine the heart beat.

Materials

- A dissected horse mussel (see activity on horse mussel anatomy)
- Seawater at 8-10°C, 15-17°C, 20-23°C and 27-30°C.
- Small bowls to cover mussel with seawater.
- Dissecting microscope
- Clock with a second hand
- Celsius thermometer

Processes	Student Discovery Activity
	1. Place a dissected mussel in a small bowl and flood the organism with seawater at room temperature.
Observing	2. Find the pericardial cavity of the mussel.
Observing	3. What is the heart rate of the mussel at room temperature?
Communicating	4. Record your findings at beats per minute.
Communicating	5. Record the temperature of the water in Celsius degrees.
	6. Replace the seawater with seawater at 15-17°C.
Communicating	7. Allow two minutes to pass; record water temperature and heartbeat rate.
Observing	8. How long did it take for the heartbeat to change when the water temperature changed?
Observing	9. Repeat step 7 with seawater at 8-10°C, and seawater at 27-30°C. Observe heartbeat and record.
Comparing	10. How does the heartbeat of a mussel in cold water compare to the heartbeat of a mussel in warm water?
Graphing	11. Draw a line graph to show heartbeat changes versus seawater temperature changes.
Applying	12. Would you expect growth and reproduction to increase or decrease in winter, spring, summer? Why?
	13. Clean up your work area and discard your mussel.

The Beat of a Mussel
Post-Lab

Possible Answers to Questions

3. This answer will vary.
8. Sometimes this change is almost immediate, with a very few beats then settling down to a regular rhythm. Occasionally the heart will appear to stop entirely, then resume a regular beat in two to three minutes.
10. Colder water should slow the heart rate while warmer water should increase the rate.
12. Growth and reproduction depend on protein synthesis and energy release (metabolism) so they will increase in spring and summer and slow in winter.

Discussion

Most students should obtain data. Students will be able to observe the heartbeat and see variations of it at different temperatures with comparative ease.

Evaluation

Expect variations in heartbeat due to the observation techniques employed by the students.

Follow-Up

- The same activity could be done with **Mytilus**. Compare the results obtained with **Mytilus** with **Modiolus**.
- Observe the ciliary feeding habitats of **Modiolus**.

References

Philip, Raleigh T. **Marine Aquarium Laboratory Manual**. Chicago, Illinois: Jewel Industries, Inc.

Sumich, James L. and Dudley, Gordon H. **Laboratory and Field Investigations in Marine Biology**. Dubuque, Iowa: Wm. C. Brown Company Publishers, 1980.

Mussel Power

Level: 9-12

Pre-Lab

Concept

- Adaptation to adverse conditions

Facts

- Mussels are sessile as adults.
- The hooked mussel **(Brachidontes recurvus)** is common in all the bays on the Texas Gulf Coast.
- Small mussels (3mm-12mm) can be removed from one substrate and placed into another.
- The "spinning" of the byssal threads can be observed with a magnifying lens.

Suggested Prerequisite Skills

- Given numerous hooked mussels, the student will notice that mussels can detach from one substrate and reattach themselves on a different substrate.
- By watching more than one mussel, the student will decide if a definite pattern of movement occurs.
- Given numerous mussels, the student will notice that the size of the mussel determines whether reattaching occurs.

Materials, Cautions

Materials

- Small culture dishes
- Seawater
- Mussels
- Razor blades

Cautions

Sometimes it may take an hour or more before a mussel disturbed from one setting will begin moving about and seeking a new attachment place. The mussel should be removed one to two hours before the class period. If you remove them more than two hours in advance, you may find them attached to another object before the class period begins.

Many small mussels can be found attached to oyster clumps in the bay. They can be removed carefully by cutting the byssal threads. Mussels should be kept in well aerated water.

These organisms can be maintained with Marine Invertebrate Food by Kordon, available from commercial aquarium stores.

Definition of Terms

Byssal Gland	A structure located at the base of the foot whose function is to spin threads.
Byssus	A mass of threads which attach the mussel to an object.
Sessile	Attached by the base and not free to move around.

Mussel Power
Student Lab

General Information

Mussels are bivalve mollusks which live on rocky shores or shallow reefs. They may be subjected to exposure at times along with waves and other turbulences. They have developed an effective way of attaching themselves to their substrate--by sprinning byssal threads which are sticky and clear when first secreted and become quite hard and firm when exposed to saltwater. Older mussels will not reattach themselves if disturbed, but babies will.

Objective

- To observe the formation of byssal threads by the hooked mussel (Brachidontes recurvus) which lives on the oyster reefs of Texas bays.

Materials

- Small mussels (3mm-12mm)
- Aerated seawater
- Small culture dish

Processes	Student Discovery Activity
	1. Place the mussel near the center of a petri dish and cover it with seawater.
	2. Observe the following movements carefully: the way the muscular foot protrudes from the ventral opening between the two shells; and the foot being drawn back into the shell. What is left behind? Notice the foot being pushed out again. What direction is it pushed through the shells?
Observing	3. After 30 minutes what type of thread network can you observe?
	4. Gently try to dislodge the mussel.
Observing	What has taken place?
Inferring	Why has this happened?
	5. Observe the threads after 24 hours.
	6. Gently try to dislodge the mussel.
Observing	What has happened?
Comparing	Compare this to step 4, and write down any differences.
	7. Detach the mussel and see if it will start all over again.
	8. Take an older mussel and place it in the culture dish of aerated seawater.
Designing an investigation	How could you find out if it attaches itself as easily to an object as a young mussel does?
	9. Return the mussels to their proper environment at the conclusion of the activity.

Mussel Power
Post-Lab

Possible Answers to Questions

2. A tiny thread is attached to the foot. Foot changes direction.
3. A small thread network.
4. Mussel has attached itself to the object. Answers will vary.
6. Mussel has remained attached to the object. A lot harder to detach than in step 4.
8. Answers will vary. The older mussel, however, will not attach itself to an object readily.

Discussion

Discuss the value of attachment with students, especially for organisms adapted to a habitat of changing currents, waves, turbulence and exposure. Older mussels direct their energies to reproductive processes and survival. The student should, with a little patience, observe the attachment behaviors of different sized mussels.

Evaluation

You should expect your students to master the objectives. A few of the student responses will vary but this is to be expected.

Follow-Up

Mussels do well in the laboratory and many experiments can be done by varying the technique to show how different physical factors affect the thread formation (pH, salinity, temperatures, etc.). Place a few mussels in a quart jar with aerated seawater and note their movement. What might be the adaptive value of this movement?

A Marine Population and Changing Times

Level: 9-12

Pre-Lab

Concept

- Micro-environments

Facts

- There are many types of micro-environments.
- Micro-organisms live in micro-environments.
- Micro-organisms serve as a food source for other animals.
- Natural succession of populations are found in micro-environments.
- Physical factors affect the life of micro-organisms in a micro-environment.

Suggested Prerequisite Skills

- Students must be able to use a compound microscope.
- Student must be able to calculate the frequency of occurrence for organisms.
- Student should be able to use keys to identify organisms.
- Student must be able to run simple tests for salinity, pH, oxygen, ammonia and nitrogen in each water sample.

Student Performance Objectives

- Given numerous marine micro-organisms, the student will calculate the occurrence frequency of each.
- Given different micro-organisms, the student will, where possible, identify them.
- Given many samples of seawater, the student will run several simple tests for salinity, pH, oxygen, ammonia and nitrogen.

Materials, Times, Cautions

Materials

- Large culture dishes, bowls or battery jars
- Fresh saltwater
- Aerator
- Compound microscope
- Marine micro-organisms key
- Centrifuge (optional)
- Eye dropper
- Slides
- Graph paper

Time

This activity will take six weeks to complete.

Cautions

Use freshly collected seawater. Place the seawater in a bowl with an aerator. If phytoplankton is plentiful and a grow light is available, aeration is not necessary.

A Marine Population and Changing Times
Student Lab

General Information

Many times an old tire near the water's edge, a small rock-rimmed pool or a depression in the sand will fill with high tide water and be isolated for a period of time. Micro-organisms are found in these places. Gradually the seawater will become saltier and evaporate and waste products will accumulate, affecting the natural succession of populations within this environment. How do physical factors affect a population in a confined space? This question along with others will be investigated in this activity.

Objectives

- To gain knowledge of how physical factors influence a group of organisms in a confined space.
- To determine the occurrence frequency of a micro-organism population.

Materials

- Large culture dish, bowls or battery jars
- Fresh seawater
- Aerator
- Compound microscope
- Slides
- Eye dropper
- Graph paper

Processes	Student Discovery Activity
	1. Place a liter of freshly collected seawater in a bowl or small battery jar. Use an aerator if there does not seem to be much plant life. If there is a lot of algae, the aerator is not necessary, but the container should be put under a florescent or grow light.
Observing	2. Examine the water carefully, looking at several slides. If a centrifuge is available use it to concentrate the micro-organisms.
Communicating	Describe what you see through the microscope.
Observing	3. Examine any solid material you can see.
Collecting data	4. Record all the organisms you find. If you have books to help you identify the organisms, record their scientific names. If not, classify them and describe each different type.
Collecting data	5. Determine the organisms you think are dominant and calculate their occurrence frequency as follows:
	a. Write the names of three or four dominant organisms on your paper.
	b. Examine at least 20 fields through the microscope.
	c. If organism 1 occurs in the first field, put a tally mark beside its name. Do not count or consider numbers. Then check to see if organism 2 is in the field of vision, etc.
	d. Look at the second field and repeat the tallying until 20 fields are examined.

Table: Dominant Organisms Observed in 20 Fields

Dominate Organisms	Tally	Occurrence Frequency
small oval ciliate		55
nematode		35
cigar shaped diatom		70
long thin diatom		50

The occurrence frequency is calculated as follows:

$$\text{Occurrence frequency} = \frac{\text{number of fields in which organism was seen}}{\text{number of fields observed}}$$

Example: Occurrence frequency of small oval ciliate = $\frac{11}{22}$ or 55 percent

e. Record the occurrence frequency of the dominant organisms every two or three days for six weeks.

Graphing

f. Graph your results.

Collecting data

6. In each sample of seawater determine the physical factors such as temperature, salinity, pH, dissolved oxygen, ammonia, minerals, etc. Record your answer in a table.

Interpreting data

7. Construct a graph to illustrate changes in populations with changes in physical factors.

A Marine Population and Changing Times
Post-Lab

Possible Answers to Questions

Each seawater sample can result in a different succession of population. Changes in the seawater are usually observable within a few days.

Discussion

This is an excellent study in which to study the natural successions of populations. Students should have reasonable success with this experience, and should see a correlation between physical changes and the occurrence frequency of organisms.

Evaluation

Occurrence frequency is a good technique, even though it is somewhat qualitative, to determine the size of a population. It should be noted that a few organisms appear to "fade out," but are still present at a low level. Students should observe some feeding.

Follow-Up

- Correlate the feeding habits with the order of succession of different groups.

Cautious Crabs

Level: 9-12

Pre-Lab

Concept

- Most organisms have a "built-in" behavior response.

Facts

- Hermit crabs take up residence in deserted gastropod shells.
- Hermit crabs are scavengers.
- Hermit crabs have "right-handed" abdomens.
- As a hermit crab grows it moves into a larger shell.
- The posterior of a hermit crab's body is softer than the rest of its body.
- Hermit crabs are crustaceans.

Suggested Prerequisite Skills

- Students must be able to report visual observations in written form.
- Students must be able to collect and record data.

Student Performance Objective

- Given a hermit crab, the student will observe habituation.

Materials, Times, Cautions

Materials

- Hermit crabs
- Culture dishes
- Pen or pencil
- Watch or clock with second hand
- Marine aquarium

Time

This activity will take one class period for 15 days.

Cautions

Students must be patient. It may take a period of time (often longer than one class period) before the hermit crab leaves its shell.

Definition of Terms

Habituation The loss of responsiveness to repeated stimulation.

Cautious Crabs
Student Lab

General Information

Studies of animal behavior have shown some actions are learned while others are inherited. Since overall environmental conditions tend to remain stable for long periods of time, many behavioral responses can be inherited with advantage and little potential danger. It is wise for a hermit crab to stop what it is doing and withdraw into its shell or scuttle away whenever confronted with anything large and moving. On the other hand, it clearly would be wasteful for a crab to hide whenever anything large moved close to it. With its relatively simple nervous system, a crab could hardly be expected to recognize every sort of seaweed or harmless fish that might pass. The crab must be capable of learning not to respond when some repeated event proves to be harmless. This loss of responsiveness to repeated stimulation is called habituation.

Objective

- To observe habituation in hermit crabs.

Materials

- Hermit crabs
- Culture dishes
- Watch or clock with second hand
- Large marine aquarium
- Pen or pencil

Processes	Student Discovery Activity
Observing	1. Put a crab in a culture dish and wait until it comes out of its shell.
	2. Gently rap on the table with a pen or pencil.
Observing	Does the crab withdraw into its shell?
Measuring	If not, tap again. If not, try one more time. Taps should be no more than one second apart.
	3. Repeat this process each day until your crab no longer responds to three successive taps.
Communicating	4. Record your data in Table 1.

Table 1 - Hermit Crab Response to Stimuli

Hermit crab: My Crab															
Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Number of taps before crab returns to shell															

Comparing 5. Add your data to the class data and average it; record the average in Table 2.

Table 2 - Hermit Crabs' Average Response to Stimuli

Hermit crabs: Class Total															
Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Class taps (average)															

Graphing 6. On a graph show how crabs in your class respond to the stimulus each day.

Designing 7. What would you do to find out if your hermit crab habituated faster than your classmates?

Comparing 8. Compare how fast your crab became habituated with other members of your class.

Communicating 9. Summarize your findings.

Cautious Crabs
Post-Lab

Possible Answers to Questions

Responses to questions will vary.

Discussion

Students study animal behavior in this activity, but they will need to be patient and still to be able to observe the crab's behavior. It may take several minutes before the hermit crabs leave their shells. Students should have reasonable success with the activity.

Evaluation

You should expect reasonable success. Many of the responses will vary since the techniques employed by each student will vary.

Follow-Up

- Do the experiment How Do Hermit Crabs Select Shells.
- "Behavior of Exposed Hermit Crabs" laboratory exercise, pp. 45-46 in Marine Biology (Sumich and Dubley).
- "Adaptations to Salinity Variations" laboratory exercise, pp. 46-48 in Marine Biology (Sumich and Dubley).
- "Food Detection in Hermit Crabs" laboratory exercise, p. 29 in Marine Aquarium Laboratory Manual (Philip).

References

Philip, Raleigh T. **Marine Aquarium Laboratory Manual,** Chicago, Ill: Jewel Industries Inc., 1976.

Spotte, Stephen. **Marine Aquarium Keeping,** New York, N.Y. John Wiley and Sons, 1973.

Sumich, James L. and Dubley, Gordon H. **Laboratory and Field Investigations in Marine Biology,** Dubuque, Iowa: Wm. C. Brown Company Publ., 1980.

Feeding and Fighting Power of a Sea Anemone

Level: 9-12

Pre-Lab

Concept

- Animal feeding behavior

Facts

- The sea anemone (Bunodosoma cavernata) is a common organism of the coastal jetties and groins.
- The sea anemone may be collected during very low tides.
- The sea anemone captures its prey with the use of stinging cells called nematocysts.
- Nematocysts (stinging cells) are coiled tubes which contain toxin-bearing barbs.
- The sea anemone swallows its prey and ingests it in the gastrovascular cavity.
- Indigestible materials pass from the body through the mouth.
- Adding 10 percent acetic acid to the tentacle of a sea anemone will cause the nematocysts to discharge.

Suggested Prerequisite Skills

- The student must be able to make a wet mount slide.
- The student must be able to use a compound microscope.

Student Performance Objectives

- At the end of the activity, the student will correctly label a drawing of a sea anemone.
- Given a sea anemone, the student will write a description of its feeding processes.
- Given a sea anemone, the student will observe a discharging nematocyst through the microscope.

Materials, Times, Cautions

Materials

- Sea anemone attached in a beaker of seawater
- Living food (a small fish or earthworm)
- 10 percent acetic acid
- Compound microscope
- Slide
- Cover slip

Time

This activity should take one hour. If students want to observe rejection of indigestible material, it may take an hour and 45 minutes.

Cautions

- Placing live brine shrimp in the water may help keep the sea anemone in a feeding posture.
- Do not overfeed. Food that is not eaten and is allowed to collect will spoil and cause bacterial growth.

Definition of Terms

Body wall	Three layers make up the wall: epidermis, or outer cell layer where nematocysts and digestive glands occur; and mesoglea, noncellular layer.
Pedal disk	The attached end of the anemone.
Sphincter	The sphincter muscle, found below the oral disk, which closes the upper end of the column of the oral disk.
Oral disk	The upper surface of the anemone which bears the mouth.
Mouth	The slit-shaped opening to the internal body cavity (gastrovascular cavity).
Siphonoglyph	A ciliated groove by which water currents are directed into the interior of the sea anemone. This produces a skeleton by water pressure.
Tentacles	The hollow appendages of the body which bear nematocysts.
Nematocysts	Stinging cells; long, barbed filaments that remain coiled inside cells on the tentacles. They function in food-gathering and defense.
Acontia	Straight or coiled threads which are located in the lower part of the body. They are armed with nematocysts. In freshly collected anemones the acontia may be exuded.
Pharynx	A tube leading from the mouth into the body cavity. The pharynx may be inverted occasionally.

Feeding and Fighting Power of a Sea Anemone
Student Lab

General Information

The sea anemone **(Bunodosoma cavernata)** is a common inhabitant of coastal jetties and groins. The sea anemone looks like a flower (for which it was named) but is actually a member of the jellyfish phylum (Cnidaria). It is closely related to corals. It lives attached just below the waterline and may be collected only during low tides. The sea anemone can crawl. When captured on the jetty, this organism may be covered with bits of small clam shells which protect it from drying out, sunburn or being eaten by predators.

Objective

- To label a drawing of a sea anemone.
- To observe the feeding habits of a sea anemone.
- To observe a discharging nematocyst through a microscope.

Materials

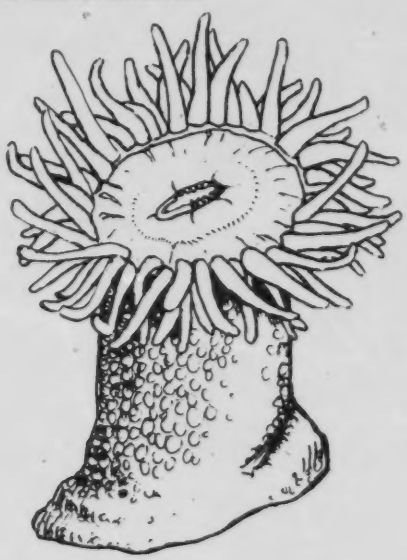
- A sea anemone attached in a beaker of seawater
- Living food (a small fish or earthworm)
- 10 percent acetic acid
- Microscope
- Slide
- Cover slip

Processes

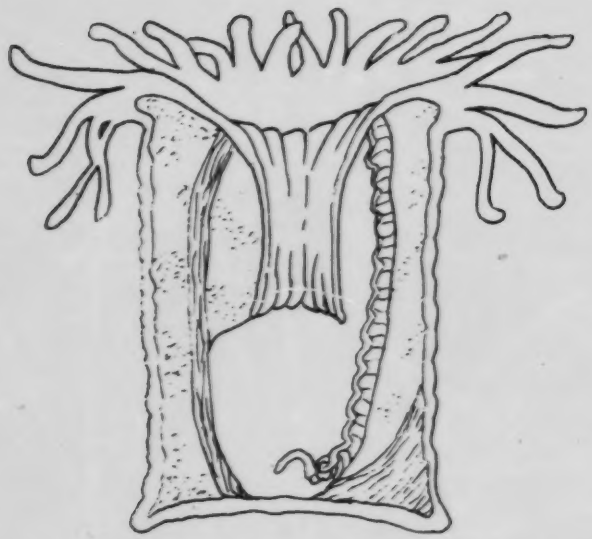
Student Discovery Activity

1. Place the beaker containing the sea anemone on a paper towel on your lab table.
2. Label the drawing of the sea anemone: Body wall, pedal disk, sphincter, oral disk, mouth, siphonoglyph, pharynx, tentacles and nematocysts. Take note of how each structure appears on the sea anemone.

Communicating



Communicating



Observing Communicating	3.	Drop a live fish or earthworm into the beaker. If the fish does not blunder into the sea anemone's tentacles in a few minutes, help it along. Record what happens in the feeding process.
Inferring	4.	What do you think immobilized the fish or earthworm?
Observing	5.	What happened to the fish or earthworm?
Hypothesizing	6.	What do you think will happen to the indigestible materials?
	7.	Remove a portion of one of the anemone's tentacles with a pair of forceps and scissors.
	8.	Place the tentacle on a clean glass slide in one drop of seawater.
	9.	Place a cover slip over the tentacle and observe through the low power objective of a compound microscope. When the edge of the tentacle is in perfect focus switch carefully to the high power objective.
	10.	Place a drop of 10 percent acetic acid at the edge of the cover slip and observe the edge of the tentacle.
Observing	11.	What evidence do you have from observing the tentacle that something happened?

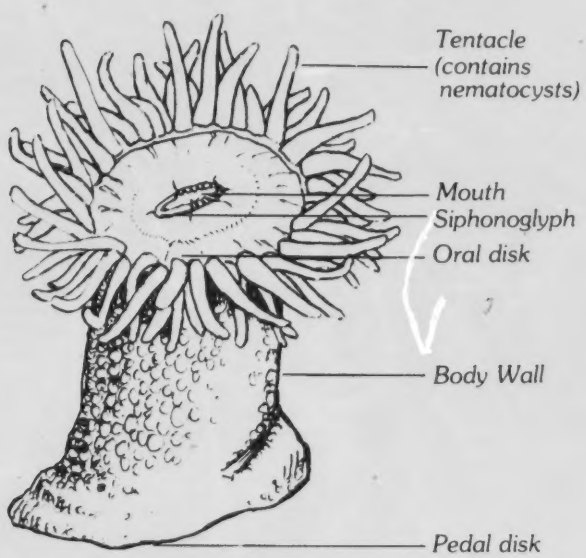
Definition of Terms

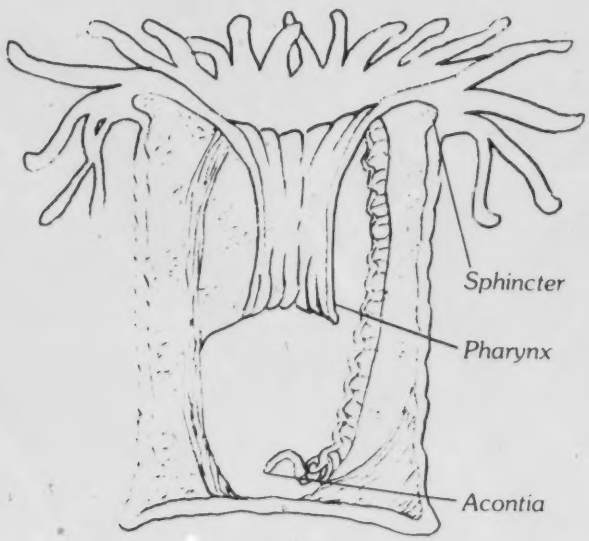
Body wall	Three layers make up the body wall: epidermis, or outer cell layer; gastrodermis, inner cell layer where nematocysts and digestive glands occur; and mesoglea, noncellular layer.
Pedal disk	The attached end of the anemone.
Sphincter	The sphincter muscle, found below the oral disk, which closes the upper end of the column of the oral disk.
Oral disk	The upper surface of the anemone which bears the mouth.
Mouth	The slit-shaped opening to the internal body cavity (gastrovascular cavity).
Siphonoglyph	A ciliated groove by which water currents are directed into the interior of the sea anemone. This produces a skeleton by water pressure.

Tentacles	The hollow appendages of the body which bear nematocysts.
Nematocysts	Stinging cells; long, barbed filaments that remain coiled inside cells on the tentacles. They function in food-gathering and defense.
Acontia	Straight or coiled threads which are located in the lower part of the body. They are armed with nematocysts. In freshly collected anemones the acontia may be exuded.
Pharynx	A tube leading from the mouth into the body cavity. The pharynx may be inverted occasionally.

Feeding and Fighting Power of a Sea Anemone
Post-Lab

Possible Answers to Questions





3. Answers will vary. Possible points that may be noticed include: The tentacles seemed to stick to the organism (the nematocysts). The tentacle wrapped around the organism, further entrapping it. The food organism was still able to move somewhat as it was drawn to the mouth. The food was swallowed. It might be moving as indicated by movement of the sea anemone's body wall. Inedible material coated with mucous was ejected from the mouth within one to two hours.
4. The nematocysts.
5. The fish or earthworm was wrapped with a sticky material or barbed with poison.
6. The indigestible material will be ejected through the mouth. This material usually is covered with mucous.
11. A discharge of nematocysts which appears as threads shooting out from the surface of the tentacle.

Discussion

- Explain the sea anemone's phylogenetic place as an organism in phylum Cnidaria.
- At the conclusion of the laboratory explain that the medusa and polyp stages of the sea anemone are closely related to the coral and sea pansies in class Anthozoa.

Evaluation

Inspection of the labeled drawing should indicate how much of the anatomy the student has learned. The answers to the questions on feeding should indicate that nematocysts are involved in capture of prey and that only one body opening is present.

Follow-Up

Place several similar sized sea anemones in a tank after measuring the height and diameter of each. Feed half the sea anemones fish fillet chucks for several weeks. Starve the other group. Measure the two groups at the end of the period. As this experiment demonstates, sea anemones grow when fed and shrink when starved. The starved sea anemone should not be permanently damaged by this activity and will respond with feeding.

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Drilling for Food

Level: 9-12

Pre-Lab

Concept

- Anatomy of the oyster drill

Facts

- The southern oyster drill is predaceous.
- A predaceous animal feeds on other animals.
- The southern oyster drill is predaceous on oysters, clams and barnacles.
- The drill bores through or between the shells of clams.
- The drill reproductive rate is tremendous due to the many eggs laid and the high percentage of larvae that live to adulthood.
- The female can produce 100 egg cases, each of which contains 900 eggs.
- The drill lives on the jetties and groins of the Gulf of Mexico and the lower bays.
- The drill does not live in salinities below 10 percent.
- Heavy rains kill drills on oyster reefs.
- There are two subspecies of drills, **Thais haemostoma floridana** and **T. haemostoma haysae.**

Suggested Prerequisite Skills

- The student must have patience with these organisms.
- The student must be able to use a hand lens or dissecting microscope.

Suggested Performance Objectives

- At the end of this activity, the student will be able to label a diagram of the **Thais** shell and a diagram of a crawling **Thais.**
- The student will observe the feeding structure (radula) of the **Thais** under magnification.

Materials, Times, Cautions

Materials

- Several live oyster drills
- Two microscope slides
- Some oyster tissue
- A container

Note: The container may be a petri dish cover or a wheaton (finger bowl) culture dish. Any container that is transparent and small enough to fit on a dissecting microscope stage will do. The oyster tissue can be obtained from the meat section of any supermarket. These oysters should be diced and frozen (save the liquid), and one pint packed in a number of individual containers should last through many experiments. Oyster drills are best collected at very low tide. They can be carried for many hours in just a little water.

Time

This activity should take one class period (55 minutes).

Cautions

- The aquarium used to store the drills should have a top on it to prevent the drills from crawling out.
- Never store any clams or barnacles in tanks with **Thais.**

Definition of Terms

Aperture	The opening to the shell of a snail.
Apex	The small, oldest part of the shell. It is the opposite end from the siphor canal.
Bivalve	A mollusk having two valves or shells, such as oysters and clams.
Body whorl	The last and largest turn in a snail's shell.
Foot	The muscular extension of the body used in locomotion.
Mantle	The outer layer or cape that secretes the shell of the mollusk.
Operculum	A shell-like or horn-like plate attached to the foot of a snail that is used to close the aperture of the shell.
Proboscis	A long, flexible tube-like extension of the mouth that contains the radula.
Predaceous	Living by preying on other animals.
Radula	A brownish, ribbon-like band bearing many rows of teeth that rasps away shell and tissue in the feeding process of snails.
Siphon	The tube used to channel the flow of water in many mollusks.
Tentacles	Two long, tapering processes of the head of a snail bearing the eyes. They extend from under the anterior (front) edge of the shell.

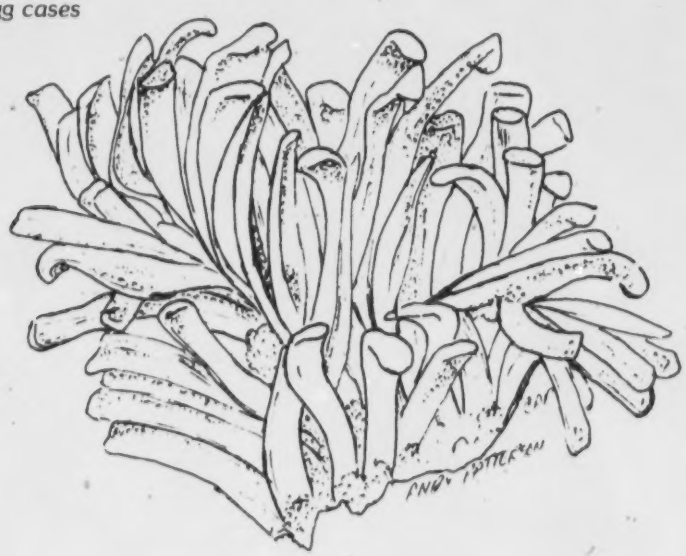
Drilling for Food
Student Lab

General Information

The southern oyster drill is a medium-sized snail. A predaceous animal, it is one of the greatest enemies of oysters, clams and barnacles from North Carolina to Central America. Using its feeding structures, the oyster drill can drill a hole between or through bivalve shells. It takes about eight hours to bore through a 2 mm shell.

It also can reproduce at a fantastic rate due to the high survival rate of the larvae and the large number of eggs produced. A female may lay about 900 eggs in a reddish-purple egg case that is attached to a rock or piling. One female may produce more than 100 egg cases.

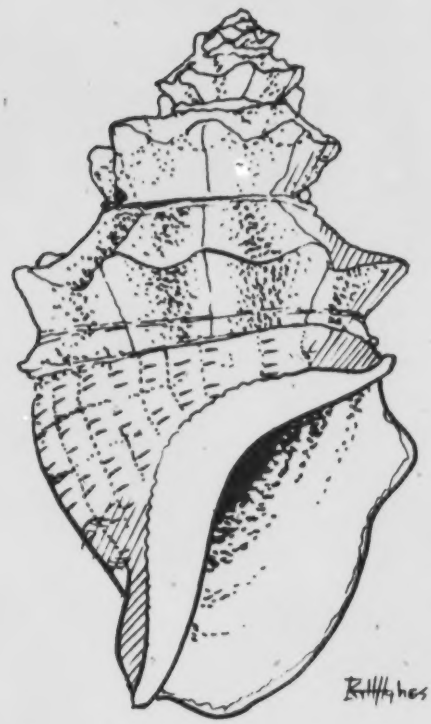
Oyster drill egg cases



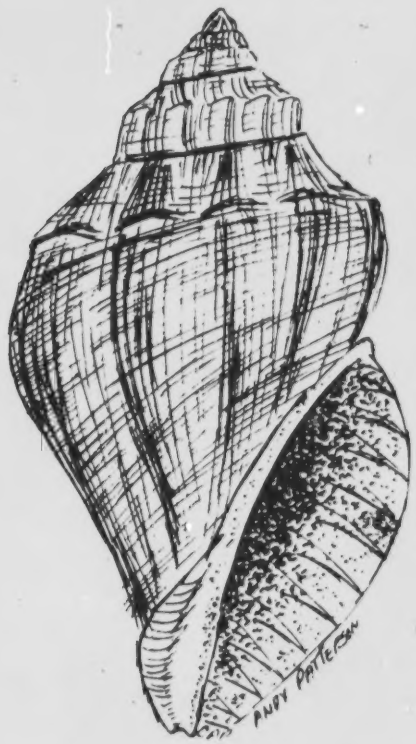
The drill lives on jetties, groins and oyster reefs in the lower bays. It kills nearly all oysters on the Gulf side of the barrier islands. Oysters can survive salinities below 10 percent, however, which will kill the oyster drill. Heavy rains and large runoffs flush the oyster reefs, and this drastically reduces the number of oyster drills.

There are two subspecies of oyster drills, **Thais haemostoma floridana**, sometimes called the Florida Rock Shell, and **T. haemostoma haysae**, the Hays Rock Shell. They are very similar in appearance; the subspecies haysae is slightly larger and has prominent bumps about its body whorl.

Thais haemostoma haysae



Thais haemostoma floridana



Objectives

- To label two drawings of oyster drills.
- To observe the feeding habits of an oyster drill.

Materials

- One or several live oyster drills
- Two microscope slides
- Some oyster tissue
- A suitable container
- A dissecting microscope or hand lens

Processes **Student Discovery Activity**

Part A - External Anatomy

1. Obtain a live oyster drill from your teacher.
2. You will be studying only the shell for this portion of the activity. (You may use an empty shell if available.)
3. Orient the shell so that the opening (aperture) is toward you and the part that looks like a screw (the apex) is pointed up.

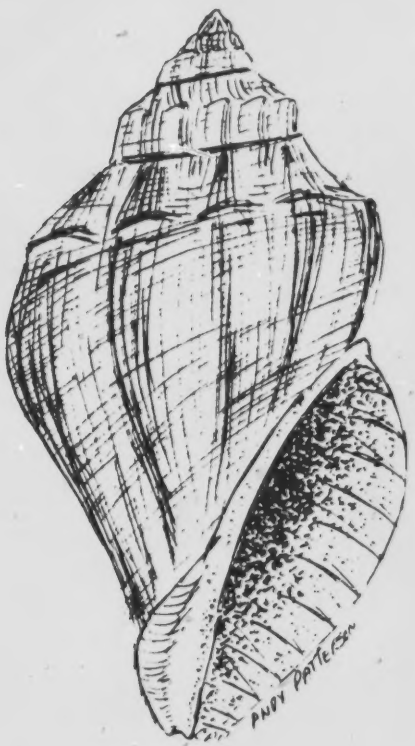
Observing

4. Is the aperture on the left or right?
5. The **apex** is the small end that is the oldest part of the shell.
6. The **siphon canal** is at the opposite end of the shell from the apex.

7. The **operculum** (not seen on an empty shell) is the trap door which closes the aperture. It functions with the shell to protect the snail from harm.
8. The last and largest revolution of the shell is the **body whorl.**
9. Label the diagram below with apex, siphon canal body and whorl.

Thais haemostoma floridana

Communicating

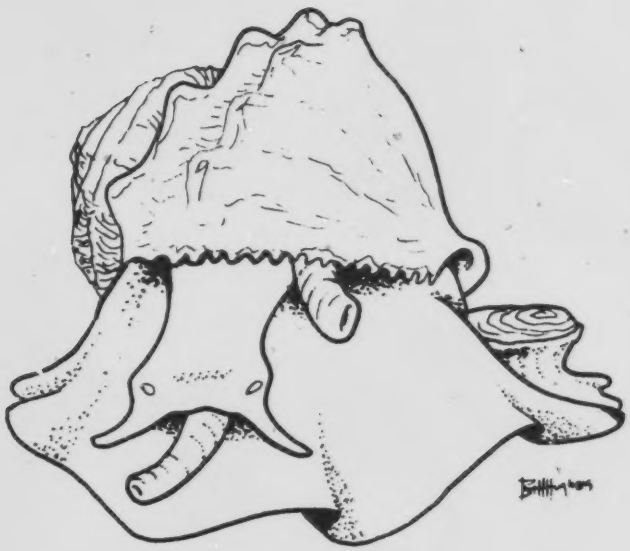


Observing

Part B - The Living Animal

10. Now observe the living animal. Notice that the snail moves on the fleshy part of its body, called the **foot.**
11. The outer layer of the animal, the **mantle,** secretes the shell.
12. The eyes are at the bottom of two stalks, called **tentacles.**
13. A long tube extends to the front of the animal. This is the **siphon** which brings in water.
14. Label the drawing below with the words foot, mantle, tentacles, siphon, operculum and proboscis (18).

Communicating



Part C - The Feeding Mechanism

15. Obtain a live oyster drill and place it in a shallow container that will fit, if necessary, on a dissecting microscope stage.
16. Obtain two glass microscope slides and make a "sandwich" with some oyster meat in the middle. Place this in the center of the glass dish.
17. Arrange the drills so that the siphon canal will point toward the glass slides. Keep the bottom moist with seawater.
18. As the snail extends his proboscis, observe the movement of the radula or rasping tongue.

Observing 19. Can you see the radula tear away some of the tissue?

Observing 20. Can you see any of the tissue being swallowed?

21. Draw a picture of the radula below.

Communicating

Definition of Terms

Aperture	The opening to the shell of a snail.
Apex	The small, oldest part of the shell. It is the opposite end from the siphon canal.
Bivalve	A mollusk having two valves or shells, such as oysters and clams.
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Predaceous	Living by preying on other animals.
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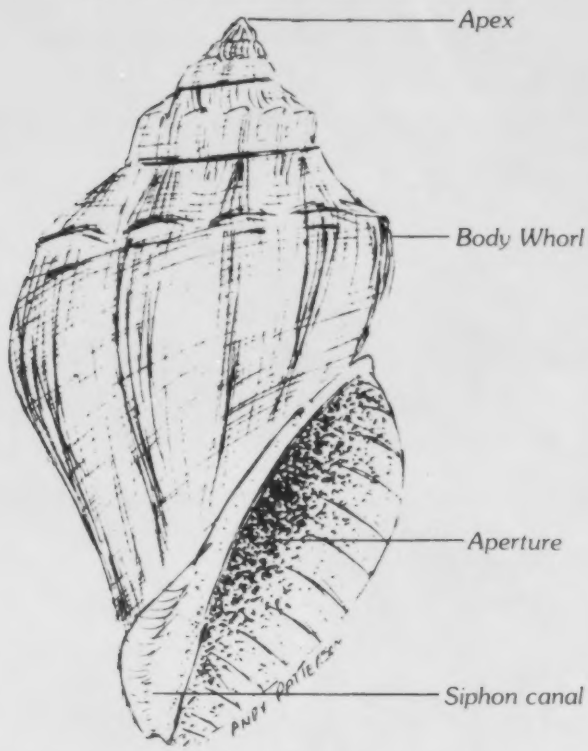
Siphon	The tube used to channel the flow of water in many mollusks.
Tentacles	Two long, tapering processes of the head of a snail bearing the eyes. They extend from under the anterior (front) edge of the shell.

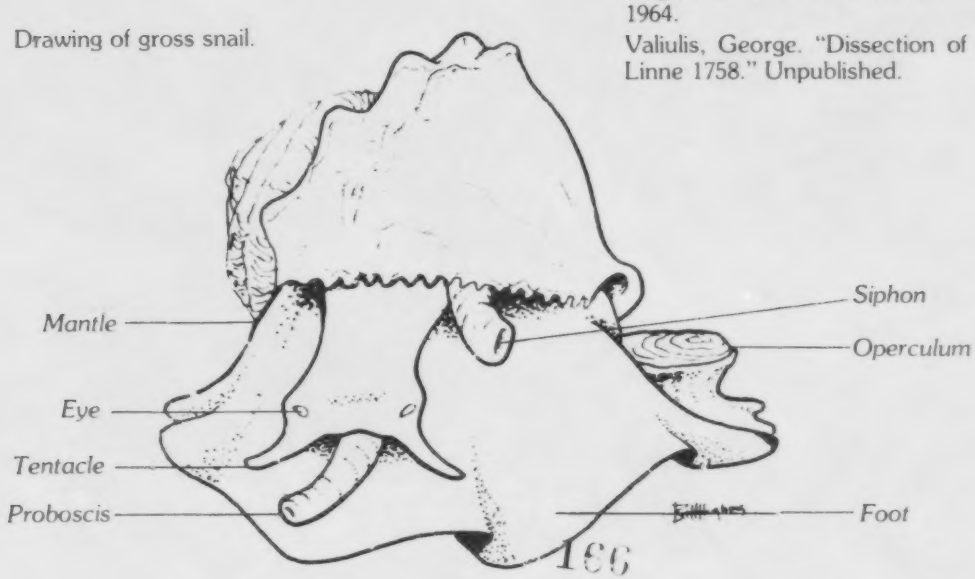
Drilling for Food
Post-Lab

Possible Answers to Questions

4. The aperture is on the right.
9. Thais haemostoma floridana



14. Drawing of gross snail.



Discussion

Thais demonstrates the role of a predaceous animal. It is dependent on its adaptations to circumvent the prey's protective mechanism. The development of a radula by **Thais** allows it to bore through the protective shells of the oyster. The oyster may live in lower salinities than the drill. This environmental limitation allows the oyster to flourish and keeps the drill in check.

Evaluation

If this activity has been successful, the student should have labeled the anatomy of this "typical" snail. The insights involved in how this organism feeds will be difficult to determine from laboratory write-ups.

Follow-Up

- Develop an activity that measures the effects of low or high salinities on the movement or feeding of **Thais.**

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Andrews, Jean. **Shells and Shores of Texas.** Austin: University of Texas Press, 1977.

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Valiulis, George. "Dissection of **Thais haemostoma** Linne 1758." Unpublished.

Is Each Link the Same?

Level: 9-12

Pre-Lab

Concept

- Polychaetes are marine annelids.

Facts

- Polychaetes are found either in a free living (errant) state or in a tube.
- Errant polychaetes have larger appendages (parapodia) than the sedentary ones.
- Polychaetes have sense organs which are used to find food, avoid enemies, etc.
- The polychaete's respiratory organ is the epidermis, which must remain moist to function.

Suggested Prerequisite Skills

- The student must be able to use a dissecting microscope.

Student Performance Objectives

- Given a polychaete, the student will identify one.
- Given a polychaete, the student will be able to distinguish anatomical features.
- Given a polychaete, the student will discover the respiratory system.

Materials, Time, Cautions

Materials

- Live polychaetes
- Petri dishes
- Seawater
- Dissecting Microscopes

Time

Forty minutes is required for this activity.

Cautions

- Do not leave the dissecting microscope's light on and overheat the polychaetes.

Definition of Terms

Commensal	A relationship between organisms of different species that live together in a close association
Setae	A stiff bristle or hairlike structure found on the bodies of certain worms and crustaceans; usual tactile.
Tactile	Pertaining to sense of touch.
Pro	First or before.
Stomial	Opening (mouth)
Poly	Many.
Chaete	Legs.
Septa	Partition which divides the coelom or body cavity into compartments.
Parapodia	Lateral appendages.

Is Each Link the Same?
Student Lab

General Information

Annelids are segmented. Their name is derived from the Latin word "annulus" which means "little ring." The marine worms, which are in the phylum Annelida, class Polychaeta, are found chiefly along the seashore.

Objectives

- To distinguish the parts of the polychaete's anatomy with its whole.

Materials (for two students)

- Live polychaete
- Petri dish
- Seawater
- Dissecting microscope
- Watercolor brush

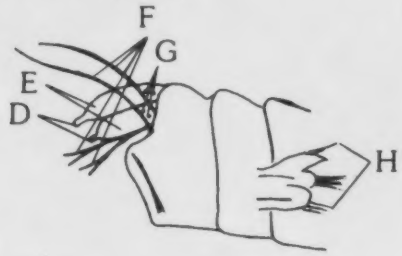
Processes	Student Discovery Activity
	1. Errant polychaetes can be found by removing a cluster of oysters from an aquarium.
	2. The cluster should "stand" for a few minutes.
	3. The polychaetes will become visible as they begin to move around.
	4. Place a small amount of seawater at the bottom of the petri dish.
	5. Take a small watercolor brush and pick up the polychaetes and place them in the petri dish.
Observing	6. Observe the segments of the polychaete through a dissecting microscope.
Inferring	7. How can you recognize the anterior end?
Observing	8. Find the parapodia (lateral appendages).
Comparing	9. How does the parapodia differ in a sedentary and errant polychaete?
Observing	10. Which type of polychaete has the largest parapodia?
	11. Using the following information, label the diagrams with the words in bold face type. A polychaete's head is formed by the **prostomium** (segment I) and the **periostomium** (segment II). The jaws can be seen when the mouth is everted. The prostomium has two short **prostomial** tentacles medially and a pair of stubby conical **palps** laterally and two pair of small **eyes** dorsally. The peristomium surrounds the ventral mouth and carries four pair of **peristomial** tentacles dorsally.
Hypothesizing	12. What purpose do you think these organs serve?
	13. The body is covered by a **cuticle** over an epidermis and beneath are layers of **circular muscles** and **longitudinal muscles.**
Inferring	14. What do you think contraction of circular muscles do to the body shape?

15. The **parapodium** is moved by **oblique muscles** in each segment. Respiration is carried on by capillaries in the parapodia and body wall.

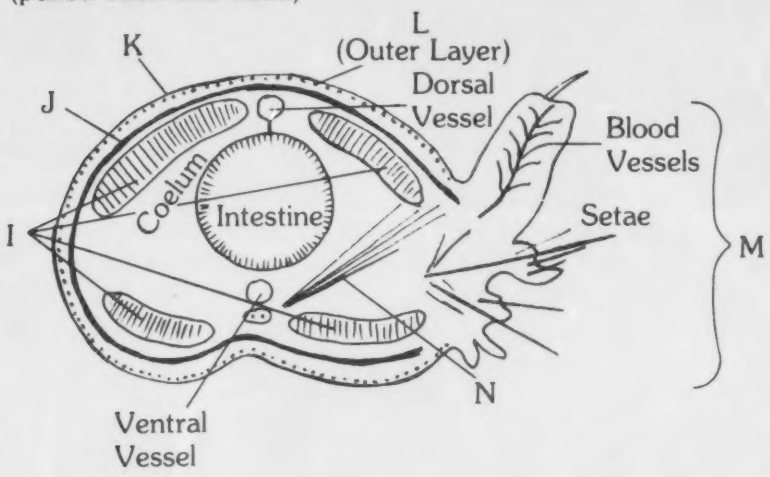
Inferring

16. In what condition do you think the epidermis must be to maintain its respiratory function?

Polychaete's anterior end with mouth everted (extended from the head)



Polychaete's anterior end with mouth retracted (pulled back into head)



Is Each Link the Same?
Post-Lab

Possible Answers to Questions

7. It moves in the direction of its head.
9. The size of the parapodia vary.
10. The errant polychaete.
12. Sense of touch, smell, and sight serve in finding food, avoiding enemies, etc.
14. Contraction of circular muscles cause the body to decrease in diameter.
16. The respiratory surface (epidermis) must remain moist to be able to absorb oxygen from the water.

Drawing: A. jaws B. prostomium C. periostomial tentacles G. eyes H. parapodium I. longitudinal muscles J. circular muscles K. epidermis L. cuticle M. parapodium

Discussion

- What advantages do errant polychaete have over tube-dwelling polychaete and vice versa?
- How can it be determined easily that the polychaetes are errant rather than tube dwellers? (Explain in terms of body structures.)
- Are the parapodia segmented or unsegmented?
- What do you think could be the function of setae on each parapodium?
- What does the presence of great vascularization in the parapodia tell you about one of its functions?
- What do you call a polychaete's skin? What is its function in many marine animals?
- Why do you think both the polychaete and the human backbone is divided into segments?

Evaluation

- To what phylum do polychaetes belong?
- To what class do polychaetes belong?
- The body is distinctly marked by transverse grooves which encircle it. These divide the body into parts. What are they called?
- How many appendages are found on these body parts?
- What are two of their functions?
- The head consists of two parts. What is the most anterior part called?
- Name the three types of muscles polychaetes possess.
- What is the function of the parapodial setae?
- What photosensory organs are located on the anterior end of the polychaete?

Follow-Up

- Study feeding mechanisms in errant and sedentary polychaetes. See Wards Scientific Establishment Filmloop-"Nereis."
- Determine the type of substrate most often inhabited by polychaetes.
- Complete the Link Behavior activity.

Life Light

Level: 9-12

Pre-Lab

Concept

- Light and photosynthesis

Facts

- Photosynthetic plants depend on light.
- Sunlight consists of many different wave lengths of light or color.
- Some wave lengths of light are more important than others for photosynthesis.
- Some species of plants differ from other species in their light requirements.
- Water absorbs different wave lengths quicker than others.
- Certain wave lengths of light are never found at certain depths.
- Depth distribution of photosynthetic plants are determined sometimes by the quality of light.

Suggested Prerequisite Skills

- Students should be able to express visual observations in written form.

Student Performance Objectives

- Given a number of microscopic organisms, students will be able to estimate population densities.
- Given standard media, students will be able to culture marine diatoms.
- Given different wave lengths of light, students will be able to determine differences in population densities of diatoms.

Materials, Times, Cautions

Materials

- Diatom culture
- Small beakers or screw cap tubes or vials
- Various colors of cellophane
- Light source
- Compound microscope
- Counting chamber or centrifuge
- Rubberbands

Time

This activity will require two weeks.

Cautions

Planktonic marine diatoms can be cultured in the laboratory by several methods. Quantitative counts can be made with a standard counting chamber slide, or students can use centrifuged samples and do counts per field.

Diatoms which tend to attach to a substrate can be cultured in a battery jar; they will be found in great abundance in mucous "sheets" clinging to the side of the jar. Careful examination of a measured amount of the scums can reveal quantitative differences; for example, average number per high power field.

Cellophanes are not complete filters, but good grades are available. If you place a sample of green cellophane over a red sample and get black you can be sure the subtraction process is in operation. The green cellophane is preventing the red from passing through and vice versa. The same test can be used with the blue and yellow cellophane.

Life Light
Student Lab

General Information

Diatoms are photosynthetic plants found in such vast numbers in the oceans that they are called the "grass of the sea." Small animals such as crustaceans graze on the diatoms and they, in turn, serve as food for larger animals. The diatoms are at the base of the marine food chain. Because of this, it is important to understand all the factors that affect the growth and distribution of these important organisms.

Objectives

- To determine if different wavelengths of light change the survival rate of marine diatoms.

Materials

- Culture of marine diatoms
- Small beakers or vials
- Different colors of cellophane
- Compound microscope
- Eye droppers
- Counting chamber or centrifuge
- Light source
- Rubberbands

Processes		Student Discovery Activity
	1.	If your diatoms are the free-floating enplankton type (check with your teacher) stir your culture to be sure you have even distribution.
Measuring	2.	Place the same amount of culture medium containing the diatoms in each of several small containers (beakers or vials).
	3.	At the beginning of the experiment determine the population density by taking a sample from each container and examining it under the microscope.
Observing	4.	Are there noticeable differences in the densities of diatoms in the different containers?
Inferring	5.	What do you think might have caused some of these changes?
Collecting data	6.	Determine the population density and record.
	7.	Leave one of the containers exposed to the fluorescent or "gro light" used to culture diatoms.
	8.	Wrap each of the remaining containers in a different color of cellophane and secure with rubberbands.
Controlling variables	9.	Determine what wavelengths of light are filtered out by the different colors of cellophane.
Observing	10.	Examine each container every 24 hours for two weeks.
Collecting data	11.	Determine the population density of diatoms in each container.

Observing	12.	What combination of colors or wavelengths seem to favor the diatoms you worked with?
Communicating	13.	Summarize your results.
Graphing	14.	Graph your results.
Predicting and inferring	15.	Do you think this experiment would have the same results if you used diatoms which live deeper in the ocean? Why?
Predicting	16.	Do diatoms respond to color or wavelengths of light the same way as an ordinary garden plant does?
Controlling variables	17.	How would you determine this?
	18.	Return the diatoms to their proper environment at the conclusion of the activity.

Life Light
Post-Lab

Possible Answers to Questions

As with all experiments of this nature, unanticipated factors may affect the results. Encourage students to repeat the experiment to find out whether they can duplicate their results. If there are some aberrant results, look for the following factors: the age of the diatom culture, inaccuracies in counting techniques, the cellophane used, etc.

White light is absorbed by the sea. Reds, yellows and violets are removed much earlier than the blues and greens (most underwater photography looks only blue-green.)

Red algae grows deeper than green and blue-green algae. Red wavelengths are reflected by red algae. They use green and blue light while other plants use different colors.

Discussion

This is an excellent activity to encourage students to repeat in an attempt to duplicate the results. Discuss the significance of duplicable results in the scientific world.

Evaluation

You should expect reasonable success with your students. A few responses will vary but this is to be expected.

Follow-Up

Ask students to try different culture media. Grow a variety of algae. Repeat this experiment and compare results.

Reference

Morholt, E., Brandwein, P.F. and Alexander, Joseph. **A Source Book for the Biological Sciences.** New York: Harcourt, Brace and World, Inc., 1966.

A "Blooming" Mangrove

Level: 9-12

Pre-Lab

Concept

- Plant germination

Facts

- Estuaries play an invaluable role in man's food chain by providing shallow protected areas for spawning and the young developing organisms we later eat as adults.
- Mangroves have an important role in land-building along the coast and in preventing erosion.
- Mangrove seeds can be germinated in a saltwater aquarium.
- Mangroves provide nesting areas for herons and egrets.

Suggested Prerequisite Skills

- The student must have knowledge of the sequence of events in seed germination.
- The student must know the difference between a monocot and dicot.

Student Performance Objectives

- The student will be able to identify a mangrove seed.
- The student will be able to germinate a mangrove seed and grow the plant.
- The student will better understand the importance of mangroves in seashore ecology.

Materials, Times, Cautions

- One mangrove seed for each student
- One 3-square inch of 1/2 inch thick styrofoam for each student
- One coffee can for each student
- Potting soil
- Allow 10 minutes classtime per week for 12 weeks

A "Blooming" Mangrove
Student Lab

General Information

The value of estuaries (wetlands, tideland, salt marshes, marshlands, etc.) has only recently become known to the general public. These areas are the spawning grounds and hiding areas for developing young of many coastal and marine organisms. Perhaps as many as 90 percent of the world's edible marine fish come from these shallow coastal waters. One of the plants which have had to make special adaptations, so that their seeds will survive, is the mangrove. Found in the warmer sub-tropical and tropical regions, it forms dense thickets which not only protect the shore from erosion but also acts as an important builder of new land. Aerial roots given off by the trunk and lateral branches establish themselves in the muddy bottom and form new systems. This forms a matrix of wood, which holds the mud and slows the water movement to allow the silt to settle. The mangrove vegetation also provides resting areas for herons and egrets. The mangrove produces a seed which drops off and floats until it is washed to shore and eventually becomes embedded in the mud.

Materials

- Mangrove seed
- Saltwater aquarium
- Three square inches of 1/2 inch thick styrofoam
- Coffee can
- Seawater
- Tray or cake pan (large enough to hold can)
- Potting soil

Processes

Observing
Inferring

Student Discovery Activity

1. Mangrove seeds will germinate while floating freely in a saltwater aquarium. Examine the seed. Has it started to germinate? How can you tell?
2. Record your data on the chart once each week.

Collecting

Organizing data

DATE	OBSERVATION
	(Include appearance of seed-color; number of cotyledons; length of root hairs, secondary roots, leaves; number of hours of light per 24 hours, etc. Make a sketch of the seed at each observation)

3. When the seed has developed a root and stem, put it in a 1.5 cm thick styrofoam cube with a center rectangle cut out slightly larger than the seed. Do not make the hole too small or it will restrict the growth of the plant.
4. Insert the seed. Allow it to float (root down) until the plant has about a 15 cm long stem with secondary roots and a 10 cm long stem with two leaves. Plant it in a coffee can filled with soil after punching small holes in the bottom of the can. Place the can in a pan of seawater. If possible, place the growing plant under a "gro-light" bulb.

A "Blooming" Mangrove
Post-Lab

Possible Answers to Questions

1. Yes, if any of the following events occurred: separation of the cotyledons, appearance of root, root hairs, secondary roots, stem or leaves.

Discussion

Ask students the following questions at the end of the activity:

1. What advantages does the mangrove seed have in being able to germinate while floating in seawater?
2. How does the mangrove function in trapping sediments washed down the rivers to the ocean?
3. How does this lead to creation of land?
4. How much marshland exists in your state? The U.S.?
5. What alternate areas (besides the mangroves) could herons and egrets use for nesting?
6. Are there groups working to save our estuaries?
7. Conduct an informal poll. Do people consider estuaries beneficial? Can they name one benefit?

Evaluation

The four questions which follow could be used as a writing experience.

1. List the sequence of events in the germination of a mangrove seed and describe the seed's appearance in each stage.
2. Are mangroves monocots or dicots?
3. Do you see any evidence that the mangrove has made an unusual adaptation to be able to live with its roots in seawater? (Salt crystals may be seen excreting from the leaves.)
4. Name two important ways man benefits from the mangrove swamps.

Follow-Up

- Alter the amount of light, salinity, temperature, etc., for experiments to measure the effects on germination rates.

Reference

Warren Schloat Productions, Inc., Marine Biome (Kit), Pleasantville, N.Y.: Prentice-Hall, Inc., 1972.

Who's Who and How Many?

Level: 9-12

Pre-Lab

Concept

- Diversity

Facts

- Different types of organisms are found in a community.
- Environmental stresses reduce diversity.
- Biological diversity can be expressed mathematically as a diversity index.
- Diversity indices can be used to compare environmental quality.

Suggested Prerequisite Skills

- Students should have an understanding of a habitat and community.
- Students should have skills in collecting, preserving and identifying common marine organisms.
- Students should have basic mathematical and graphing skills.

Student Performance Objectives

- Given a biological sample of organisms, the student will be able to randomize it.
- Given numerous organisms, the student will be able to count and compare the different types.
- Given different types of organisms, the student will be able to calculate a diversity index.
- Given different habitats, the student will be able to use diversity indices.

Materials, Times, Cautions

Materials

- Droppers
- Forceps
- Jar
- Probe
- Permanent broad tip marker
- White enamel pan or tray
- Good hand magnifier or stereo dissecting microscope
- 70 percent ethyl alcohol (or other preservative)
- Clumps of oysters from different environments

Time

This activity will take at least one class period, perhaps more if you wish to extend the variations.

Cautions

- Oyster clumps should be approximately the same size. They can be maintained in the laboratory aquaria if fed marine invertebrate food available from commercial stores.
- This activity should be done after students are familiar with the main characteristics of the major groups of marine animals.
- Diversity indices using calculus equations are available in advanced ecology tests, but this is a handy and surprisingly reliable method of allowing students to experience the mathematical bases necessary in ecological study--on a level they can handle quite well.

Definition of Terms

Diversity	The number of different types of organisms found in a particular community.
Habitat	The place where an organism lives.
Community	The interacting producers, consumers and decomposers in a given area or habitat.

Who's Who and How Many?
Student Lab

General Information

Biological diversity refers to the number of different kinds of organisms in a particular habitat. When water quality is poor or there are natural stresses (extreme cold, chemical excesses, etc.) or manmade ones (pollution, habitat destruction resulting in crowding) in the environment, the diversity generally is lowered. Communities with high diversity are called mature or complex and reflect good water quality and optimum living conditions. This diversity can be expressed mathematically as a diversity index.

Objectives

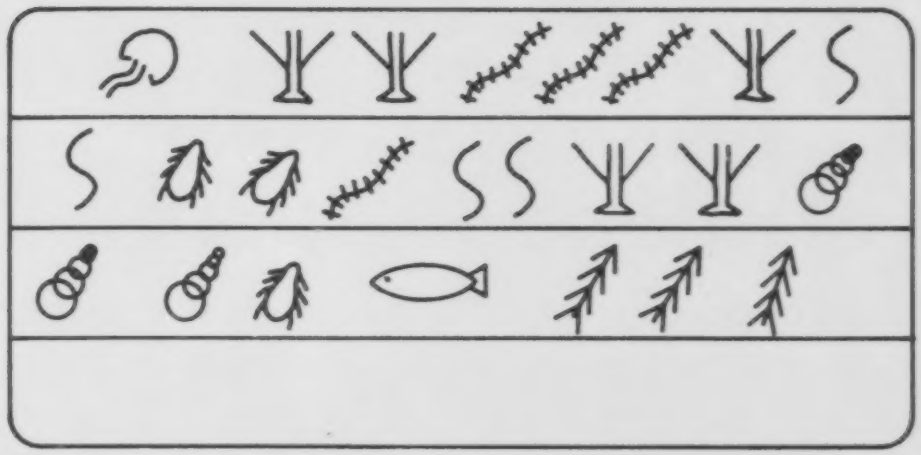
- To learn the technique of calculating a diversity index.
- To use this technique to compare two population clumps of oysters from two different environments.

Materials

- Droppers
- Forceps
- Jar
- Good hand magnifier or stereo dissecting microscope
- 70 percent ethyl alcohol (or other preservative)
- Clumps of oysters from different environments
- White enamel pan or tray
- Probe
- Permanent broad tip marker

Processes	Student Discovery Activity
Observing	1. Examine the oyster clumps very closely and collect and preserve all the invertebrate animal life you find on them.
Classifying	2. Place all organisms from one clump into a jar of preservative and label. Place all organisms from the remaining clump in another jar and label.
Measuring	3. Draw parallel lines about 2.5 cm apart in the bottom of an enamel pan or tray.
	4. Randomize your collected invertebrate from clump one by gently shaking the jar 10 seconds.
	5. Pour the contents into the enamel pan with the pre-drawn lines. Break up any clumps of organisms and, with the probe, be sure all organisms are roughly between the lines. **Do not** "arrange" the organisms, each one must stay where it fell.
	6. All organisms must be counted as they fall, the lines are just to make counting a little easier.
Measuring Communicating	7. First determine the total number of organisms in your sample. Record your result.

"Runs" of organisms in the bottom of a white enamel pan



8. Count the runs of similar organisms in this way: Start with the first organism on the left in the top space.

Observing — Place an X on your paper as a symbol for that organism.

Observing — Look at the second organism; if it is the same as the first, put another X. If it is different, put an O. (We are not concerned about tiny details of species at this time, only in such similar types as polychaetes, nematodes, anemones, amphipods, isopods, etc.)

Classifying — Continue down the spaces, left to right, using only X's and O's. Change your symbol anytime the next organism is different, regardless of what it may be.

Communicating — For example, the runs would be recorded like this for the diagram in step 5.

$$\frac{1}{X} \quad \frac{2}{OO} \quad \frac{3}{XXX} \quad \frac{4}{O} \quad \frac{5}{XX}$$

$$\frac{6}{OO} \quad \frac{7}{X} \quad \frac{8}{OO} \quad \frac{9}{XX} \quad \frac{10}{OO}$$

$$\frac{}{O} \quad \frac{11}{X} \quad \frac{12}{O} \quad \frac{13}{XXX}$$

The total number in the sample = 24
The number of runs in the sample = 13
Record the number of runs in clump one.

Communicating 9. To calculate the diversity index of clump one use:

$$\text{D.I.} = \frac{\text{number of runs}}{\text{number of organisms}}$$

Measuring 10. For example, in this illustration we have:

$$\text{D.I.} = \frac{13}{24} \text{ or } 0.54$$

Diversity Index in sample is 0.54

11. Your results will be far more accurate if you re-randomize your sample as in step 4 and repeat the procedure several times, taking an average of the D.I. for that clump.
12. Determine the D.I. for clump two the same way.

Comparing
13. Compare the two Diversity Indices.

Inferring
14. If they are different, what are the environmental factors which made this possible?

Predicting
15. What might happen to the D.I. on an oyster reef if there were a long, rainy spring season?

Designing an investigation
16. How could you find out?

17. Return preserved organisms to their proper container at the conclusion of the activity.

Who's Who and How Many?
Post-Lab

Possible Answers to Questions

7. Answers will vary.
8. Answers will vary.
12. Answers will vary.
13. Answers will vary.
14. Answers will vary.
15. Answers will vary.

Discussion

- Compare all the possible environmental factors which might determine differences and similarities.
- Be sure students do not get bogged down trying to determine fine points of difference.

Evaluation

Encourage the re-randomization to illustrate the inherent errors in a technique which is based on random samples. You should expect reasonable success with your students. Very interesting graphs can be made from these data if several different habitats can be sampled.

Follow-Up

This technique can be used on many groups of organisms, many habitats, etc., but it is best to collect all organisms in one general category, such as macroscopic invertebrates, macroscopic dune or shoreline plants, to randomize shake leaf and/or stem samples in a large plastic bag and shake out onto a table marked with masking lines.

This technique can be adapted to microscopic plants by using a ruled slide counter.

Organisms can be collected and preserved during a field experience and the Diversity Indices determined and compared at a later date.

Testing on this technique can be done by preparing several unknowns using items such as different colored beans, different sizes and shapes of nails, etc.

Salty Sponges!

Level: 9-12

Pre-Lab

Concept

- Salinity

Facts

- Organisms are adapted to survive within a given set of physical conditions.
- Organisms respond to change.
- Some organisms have a wider range of tolerance for changes in general than others.
- Some organisms have a wide range of tolerance for only a few specific changes.
- Salinity is one physical factor in the marine environment which influences many organisms.
- The boring sponge, **Cliona**, is found in many shells in estuarine habitats along the coast.
- Estuarine organisms must be able to adjust to salinity changes.

Suggested Prerequisite Skills

- Students should understand the concept of salinity.
- Students should be able to mix solutions of varying concentrations.

Student Performance Objectives

- Given a few boring sponges, students will be able to measure their mortality rate in varying salinities.

Materials, Time, Cautions

Materials

- Small glass beakers, about one liter in size
- Airline tubing and airstones
- Airpump
- Shells with live boring sponges
- Freshwater and seawater of different salinities (for example 10 o/oo, 20 o/oo, 30 o/oo, 40 o/oo, and 50 o/oo)

Time

Assuming solutions are prepared in advance, this activity will take approximately one class period to set up. Observations need to be recorded for at least one week.

Cautions

Be sure the air stone is at the bottom of the beaker. It can be placed under the shell. If one liter beakers are used, a small tubing can be placed in the lip and covered with plastic fastened to the beaker with a rubberband.

Definition of Terms

Eury	Wide.
Haline	Refers to salinity.
Steno	Narrow.

Salty Sponges!
Student Lab

General Information

Organisms are adapted to survive within a given set of physical conditions. They will respond to changes in these conditions in a way that can be measured. Some organisms have a wide range of tolerance for environmental changes while others have a very narrow range.

One physical factor in the marine environment which influences many organisms is salinity. It is possible to prepare solutions of varying salinities and test an organism's tolerance to them.

The boring sponge, **Cliona sp**, is found in many shells in estuarine habitats along the coast. They are bright yellow tufts in small holes in many kinds of shells. The live sponge chemically bores its way into the shell. (This activity eventually helps break the shells into small pieces and speeds their decomposition.)

Objectives

- To prepare solutions of varying salinity values.
- To observe the color and appearance of live sponges over a period of several days in seawater of different salinity values.

Materials

- Glass liter (or similar size) container, 6 per group
- Air tubing and airstones
- Air pump
- Shells with live boring sponges
- Freshwater and seawater of salinities of 10 o/oo, 20 o/oo, 30 o/oo, 40 o/oo and 50 o/oo

Processes		Student Discovery Activity
	1.	Place a small portion of shell with live boring sponge in each of the six one-liter beakers or container of similar size.
	2.	Label container 1 freshwater.
	3.	Cover your shell with freshwater.
	4.	Connect the airstone to a pump and begin aeration.
	5.	Label containers 2, 3, 4, 5, and 6 as 10 o/oo, 20 o/oo, 30 o/oo, 40 o/oo, 50 o/oo and cover the shells with the appropriate solution.
	6.	Aerate each container.
Observing	7.	Observe the containers daily for two weeks.
Hypothesizing	8.	What do you think will happen to the sponges in all the containers?
Observing	9.	What has happened to the sponges in all the containers?
	10.	Note any change in color of the sponge "spots" and any changes in size.
Communicating	11.	Record any changes.
Observing	12.	Where did most changes occur?
Summarizing	13.	What can you conclude about the effect of salinity on **Cliona sp**?

Hypothesizing	14.	What do you think will happen to your results if you used different temperatures?
Designing an investigation	15.	How would you design an experiment to test the effects of different temperatures on **Cliona sp** on the results you obtained?
Applying	16.	Would estuarine organisms such as **Cliona sp** be euryhaline or stenohaline?

Salty Sponges
Post-Lab

Possible Answers to Questions

8. Answers will vary.
9. The color of the sponge in each container should change.
12. Most color changes occur in salinities of 0 o/oo and 50 o/oo. In the extremes of salinity the yellow color fades rather rapidly and the tuft shrinks away from the sides of the hole. In the 10 o/oo and 40 o/oo solutions the change may be more gradual. Optimum salinities usually ranged between 20 o/oo and 30 o/oo.
13. Refer to 12.
14. Answers will vary.
15. Answers will vary.
16. Estuarine organisms must be euryhaline to survive the wide range of salinity changes found in this environment.

Discussion

- When marine organisms are maintained in the laboratory their salinity preferences and tolerances must be duplicated.
- Extreme rainfall amounts or extreme evaporation rates can result in mass mortality of estuarine organisms.
- Would you expect the sponge's salinity tolerance to be the same as that of the animal which produced the shell in which it bored? (If not, why not?) As an example, a less euryhaline organism might die from a salinity change, but the sponge may use the dead shell as a substrate and survive in different extremes of salinity.

Follow-Up

- This classical experiment in salinity tolerance can be adapted for any small marine organism.
- Criteria other than mortality can be observed in many organisms, such as movement, feeding responses, etc.
- If equipment is available so that constant temperatures can be maintained, this experiment can illustrate interrelationship of two physical factors. Some organisms are more sensitive to salinity change at extremes of temperature.
- Reading research can take more advanced students into the physiological aspects of osmoregulation.

References

Fotheringham, Nick and Brunenmeister, Susan Lee. **Common Marine Invertebrates of the Northwestern Gulf Coast**. Houston: Gulf Publishing Company, 1975.

Barnacles: How to Survive in One Spot!

Level: 9-12

Pre-Lab

Concepts

- Life cycle of an animal
- Feeding rates

Facts

- Barnacles are found growing in different places such as the bottom of ships.
- Barnacles can be fed live brine shrimp larvae.
- Barnacles are related to shrimps and crabs.
- Barnacles capture small organisms by sweeping the water with their feet (cirri).
- The barnacle larvae attach themselves by use of a cement gland which is at the base of the first attennae.
- Barnacle cement is so strong that dentists study it and try to duplicate it to use in filling teeth.
- The nauplius larvae of the brine shrimp is similar to the nauplius larvae instars of barnacles.

Suggested Prerequisite Skills

- The student should be able to make a wet mount slide.
- The student should be able to use a compound microscope properly.

Student Performance Objectives

- Given a nauplius larvae, the student will observe its similarity to a barnacle's free swimming larvae.
- Given a living barnacle, the student will observe its feeding.
- Given brine shrimp larvae, the student will compare in writing the feeding rates of barnacles.

Materials, Times, Cautions

Materials

- Living brine shrimp larvae
- Living barnacles
- Seawater
- Container
- Stop or wrist watch

Time

This activity should be completed in one class period.

Cautions

- Barnacles should be fed for 24 hours preceding the lab. The more time the barnacles are left undisturbed the quicker the response to feeding. Do not leave barnacles in tanks with snails, especially Thais species.
- Live brine shrimp larvae can be hatched in a solution of instant ocean or seven tablespoons of uniodized salt in four liters of tap water. The long-life Brine Shrimp Hatchery of Metafrane "shrimpery" may be useful for smaller amounts.
- Enamel or plastic trays may be used for larger numbers.
- Aerationtion increases the yield and shortens the time required for hatching.
- A light will attract brine shrimp.
- Live barnacles can be collected on jetties or smaller rocks (if you can find them).
- A rotting pier on the bayside offers a good source of Balanus barnacles. Just break off strips of wood with the barnacles attached.
- Barnacles also can be found growing on oyster shells.
- Barnacles can be maintained in normal seawater. They will do well on a diet of live brine shrimp larvae.
- Proper aeration is necessary. The strips of wood can be suspended from monofilament line (cotton string rots quickly) attached to dowels. This method prevents barnacles from being smothered.
- Aeration increases the yield and shortens the time required for hatching.

Barnacles: How to Survive in One Spot!
Student Lab

General Information

Barnacles are interesting animals that are often thought to be related to clams. They are really members of phylum Arthropoda, along with shrimp, crabs and insects. These stout little animals start life as an egg which hatches into a free swimming larva and eventually settles and attached itself to a hard substrate.

The barnacle's larva head attaches to a substrate and undergoes a series of changes until a recognized form is attained. It lives by sweeping its legs through the water, capturing small animals and bits of food which are placed in its mouth in the enclosed mantle.

Objectives

- To observe a larva which is similar to one of the first stages in the barnacle's life style.
- To investigate the feeding behavior of barnacles.

Materials

- Living brine shrimp larvae
- Living barnacles
- Seawater
- Container
- Stop or wrist watch

Processes

Student Discovery Activity

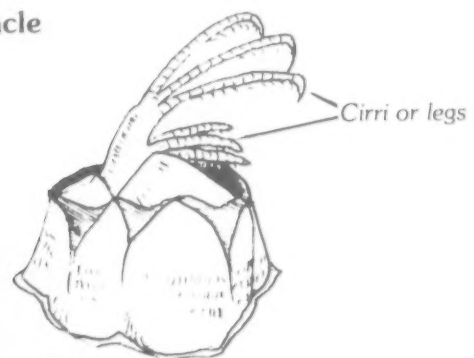
Observing

1. Put one drop of water containing several brine shrimp larvae on a microscope slide and view under low power only. Place a cover slip on the drop of water and again view on low power. If you wish, you may view briefly on high power.

Communicating

2. Draw one of the larva as viewed on low power. Note: This is a nauplius larva and very similar to the first larva stages in the barnacle life cycle. This type of free swimming larva allows barnacles to colonize new areas.
3. Obtain a beaker of seawater containing barnacles on a rock or piece of wood. Allow the water to stand for 10 minutes. Do not jiggle the table or move the beaker.

Barnacle



Observing Communicating	4.	Observe the beaker. Are the barnacles feeding (sweeping the water with their cirri or legs)? If they are feeding, have one person keep the time for 15 minutes. The other should count the number of sweeps and multiply this number by four. Record the rate of feeding per minutes.
Observing and Communicating	5.	Now pour in several milliliters of live brine shrimp larvae. Wait five minutes. Observe and obtain the rate of feeding as in step 4 above.
Predicting	6.	What do you think will happen if you hold your hand between the light and the barnacle?
Observing	7.	What happened?
Predicting	8.	What do you think will happen if you drum lightly on the table?
Observing	9.	What happened?
Comparing	10.	How did the behavior in step 7 differ from that in step 9?
Inferring	11.	How do you think barnacles use their sensory perception structures?
Hypothesizing	12.	What do you think would happen to barnacles if they did not have sensory perception structures?
	13.	Return the barnacles to their proper environment at the conclusion of the activity.

Barnacles: How to Survive in One Spot!
Post-Lab

Possible Answers to Questions

4. Yes or no. If they are, the first rate will be 60 to 80 beats.
5. The rate after introduction of live brine shrimp should be approximately 90 or 100 beats per minute.
7. Holding your hand between the light and barnacle will cause the barnacle to stop feeding.
9. Drumming on the table and thumping on the beaker will cause the barnacle to interrupt its feeding.
11. Barnacles use their sensory perception structures because of answers 5, 7 and 9.
12. They would not survive.

Discussion

Barnacles are easy to collect and maintain and can undergo periods of stress caused by being out of the water or without food. They should be excellent animals for marine science laboratories and for long-range experiments.

Evaluation

This activity may not have dramatic results but should acquaint students with living barnacles. Obtaining feeding rates should be an interesting, but simple, introduction to biological rate measurements.

Follow-Up

- Abscorbic acid (Vitamin C) affects barnacles by inducing reproductive activity. This could be used to acquaint students with reproduction among sessile organisms.
- Measuring feeding rates at different temperatures would be another follow-up activity.

References

Barnes, Robert D., Ph.D. **Invertebrate Zoology**, Second Edition. Philadelphia: W.B. Saunders Co., 1968.

Beck D. Elden and Lee F. Braithmaite. **Invertebrate Zoology Laboratory Workbook**, Third Edition. Minneapolis: Burgess Publishing Co., 1969.

Collier, Albert, Ray, Sammy and Wilson, W.B. "Some Effects of Specific Organic Compounds on Marine Organisms," **Science**, Vol. CXXIV (August 3, 1956), 220.

Fotheringham, Nick and Brunenmeister, Susan Lee. **Common Marine Invertebrates of the Northwestern Gulf Coast**. Houston: Gulf Publishing Company, 1975.

Lunch Time

Level: 9-12

Pre-Lab

Concept

- Fishes (as all living organisms) require adequate nutrition for growth and survival.

Facts

- Some fishes feed exclusively on plants (herbivores).
- Some fishes feed exclusively on animals (carnivores).
- A large group of fishes feed on both plant and animal life (omnivores).
- Natural fluctuations in abundance and availability of a particular food organism is a key factor in determining what a fish will eat.
- Fishes are tied to other forms of life in their environment by food webs (food chains or food pyramids).
- Fishes can be classified according to their feeding habits as predators, grazers, food strainers, food suckers or parasites.
- Diversity in fish feeding habits is partially due to structural adaptations such as lips, mouth shape, teeth, gill rakers and the digestive tube.

Suggested Prerequisite Skills

- Student must be able to distinguish common estuarine fishes (i.e., killifish, sheepshead minnow, **Gambusia**, toadfish, sea robin).
- Student must be able to use a hand lens or dissecting (binocular) microscope correctly.
- Student must be able to maintain a saltwater aquarium.
- Student must be able to record observations in an organized manner.
- Student must be able to do a pencil sketch of various parts of fish anatomy (artistic skill not withstanding).
- Student must be able and willing to dissect a dead fish if available.
- Student should be familiar with basic fish anatomy.

Student Performance Objectives

- Upon completing the activity the student should be able to hypothesize about the feeding habit classification of the fishes being studied (i.e., predator, grazer, food strainer, food sucker or parasite). This should be based on observations of live fish and anatomical sketches.

Materials, Times, Cautions

Materials

- Selection of small estuarine fishes maintained in a balanced aquarium (killifish, **Gambusia**, sea robins, etc.)
- Small dip net
- Dissecting (binocular) microscope or good hand lens
- Small dish (petri dish half if larger than available fishes)
- Roll of soft, absorbent sterile cotton
- Basic dissection kit (forceps, probes, eyedropper, scapel)
- Dissecting pan (if fresh dead, frozen or preserved specimens are available; **do not** sacrifice living fish)
- Information on habitats from which fishes were collected if available
- Reference books on fish, fish anatomy, marine fishes, marine ecology and ichthyology
- Identification keys for marine fishes
- Notebook (for sketches, notes and records)

Time

Observations will require at least 10 to 15 minutes per day for two to five days. One hour per fish should be allowed for microscopic examination and anatomical drawing. An additional two hours will be needed to compare reference information with observations.

Cautions

- Students should observe the fishes in the aquarium for two to five days before netting and handling them in the microscopic examination of the anatomical features. Their observations should be recorded in the notebook.
- Fish should be handled gently and carefully in the microscopic examination phase to avoid injuring them. Keep the cotton blanket moistened with aquarium water during this phase and make sure the student does not keep the fish out of the aquarium any longer than necessary to examine the anatomical features.
- If dead, frozen or preserved specimens are available for dissection, remind students of the obvious precautions and care necessary to avoid accidents with the sharp dissecting instruments.

Definition of Terms

Herbivores	Organisms which feed upon plants (adj--herbivorous)
Carnivores	Organisms which feed upon animals (adj--carnivorous)
Omnivores	Organisms which feed upon both plant and animal life (adj--omnivorous)
Predators	Organisms which hunt, seek or lie in wait to capture animals for their food.

Grazers	Organisms which browse and nibble or bite off parts of plants or animals which many be stationary or moving slowly.
Strainers	Organisms which swallow or pump quantities of water through filtering devices such as gill rakers to collect the plants or animals in that water as their food supply.
Suckers	Organisms which consume their food by sipping or drawing into the mouth by suction plants, animals or detritus found on surfaces on which they feed, such as sediments, rocks or other organisms.
Parasites	Organisms which inhabit other organisms and depend on them for food supply.

Lunch Time
Student Lab

General Information

Marine fishes, as all animals, require adequate nutrition for growth and survival. They are tied to other forms of life in their environment by food webs. Some fishes feed on plant life (herbivorous) and others feed on animal life (carnivorous). A large group feeds on both plant and animal life (omnivorous).

A fish's feeding behavior is greatly influenced by some of its particular body structures, such as lips, mouth shape, teeth, gill rakers and digestive tube. It also is influenced by the body shape, bulk, coloration (camouflage) and the speed and agility with which the fish is able to move in the water. By recognizing many of these factors, observing the fish during feeding and, in some cases, examining the stomach contents, it is possible to classify a fish as a predator, grazer, food strainer, food sucker or parasite.

Objective

- To investigate the feeding habit classification of several common marine fishes.

Materials

- A marine aquarium stocked with an assortment of fishes (preferably killifish, Gambusia (mosquito fish), sheepshead minnow, sea robins)
- Small dip net
- Dissecting (binocular) microscope or good hand lens
- Small dish (petri dish half if larger than the available fishes)
- Roll of soft, absorbent sterile cotton
- Several cotton-tipped swabs
- Basic dissection kit (forceps, probes, eyedropper, scalpel, etc.)
- Dissecting pan (if fresh dead, frozen or preserved specimens are available; do not sacrifice live fish)
- Information on habitats from which fishes were collected if available
- Reference books on fishes, fish anatomy, marine fishes, marine ecology, ichthyology
- Identification keys to marine fishes
- Notebook for sketches, notes and records

Processes		Student Discovery Activity
Observing	1.	Observe two or three different species of fish in your marine aquarium each time food is added.
Communicating	2.	In your notebook, describe where each species feeds (at top of water, mid-water or on bottom). Record how quickly each type discovers the food and how each type feeds (i.e., nibbling, swallow large bits whole, direct attack, discover food while cruising about the tank, etc.). Keep records of these observations for two to five days.
Measuring	3.	After recording observations of feeding behavior for several days, prepare to examine live fishes with a microscope or hands lens as follows:

a. Fill the small dish about half full with aquarium water (saltwater) using an eyedropper.
b. Pull off a square of cotton (large enough to fold over fish) for each species you will examine. Moisten the cotton with aquarium water.
c. Set out forceps, probes and cotton-tipped swabs and prepare the microscope or hand lens for viewing. Keep a pencil and notebook nearby.

4. Catch a fish with a dip net and place it on the top half of a moistened square of cotton. Carefully fold the cotton to cover the fish. Gently pull the cotton apart to expose the head and gill cover.

Observing 5. Carefully place the wrapped fish into the dish of water and examine the head, lips and mouth size and location with the microscope or hand lens. Make a sketch of these parts.

Communicating 6. Carefully open the fish's mouth and use a swab or probe to examine teeth. Sketch shape, size and position of teeth.

Communicating 7. Carefully open gill cover with swab and note size, shape and quantity of gill rakers. Sketch these.

8. Add aquarium water to the cotton occasionally with an eyedropper while the fish is under the cotton and again when the examination is finished.

9. Gently unwrap the fish and return it to the aquarium.

10. Optional step: If a fresh dead, frozen or preserved specimen is available, open the fish from the gill cover to the vent (anus) and note size, shape and length of the digestive tube. (Use dissecting kit, pan and hand lens.) Is it coiled, straight, enlarged or branched? Does it have a readily distinguishable stomach, "gizzard," intestine, etc? Sketch it in the notebook.

Communicating

11. Study reference material provided under sections entitled: Feeding habits, digestive system, teeth, mouthparts, feeding behavior, food habits, food webs or chains, feeding adaptations, or related topics referring to fish feeding.

Observing 12. Study your observations, notes and sketches and compare with reference book information.

Hypothesizing 13. Now that you have compiled data, observations and notes, have made examinations and sketches and have compared your information with that in reference books, devise a hypothesis as to the feeding habit classification (i.e., predator, grazer, food strainer, food sucker or parasite) of the fishes being studied.

Observing 14. Which species of fish was most responsive to food added to the aquarium?

Communicating 15. Were you able to observe differences in where the various species feed (surface, mid-water, bottom, etc.)? If so, describe which fish types preferred what depths.

Observing 16. Did any of the fishes not eat?

Observing 17. Did you see differences in the lips, the mouth location and/or mouth size between the different species examined? What does this tell you about their feeding habits?

Observing 18. Are there differences in size, shape or location of the teeth in the species examined?

Inferring 19. What do tooth types tell you about how a fish eats?

Observing	20.	Are there differences in size, shape or quantities of gill rakers of the several species examined?
Inferring	21.	What do gill rakers tell you about how a fish eats?
Inferring	22.	From your reading in reference books can you explain what the different shapes or sizes of digestive tubes (intestines) tell you about fish feeding habits?

Lunch Time
Post-Lab

Possible Answers to Questions

14. Depends on which species are used, possibly on time of day, type of food, where it is placed, time elapsed since last feeding, size of fishes, etc. This question is to help students sharpen their skills of observation, comparison and data recording.
15. Answers may vary. Some of the same variables apply as in question 14.
16. Same as question 15.
17. Varies with species used. Lip differences are obvious in those species which suck their food from some surface. Mouth location can give clues as to whether a fish is an active predator, a grazing bottom feeder, etc. Mouth size will vary in predators, bottom feeders, food strainers, etc. See reference books for specific details and complete discussion.
18. There should be obvious differences between species in tooth size, shape and specific location within the mouth.
19. Tooth type, size and location is an excellent clue to feeding habits. For example, canine teeth (elongated, straight or curved) are adapted for grasping, piercing and holding required in an active predator catching active prey. Incisors (shapely edged cutting teeth) are found in fish which graze and nibble or bite off small bites of slow-moving or inactive food types. See reference books for more complete discussion.
20. Gill rakers found in the species will vary in number or size depending on how much the fish relies on straining the water it ingests to obtain planktonic organisms for food. Answers will vary according to the types of fishes.
21. Very specialized gill rakers adapted for fine straining of ingested water are found on plankton feeders. They are often elongated, very numerous and sometimes feather-like to provide an efficient straining network as elements overlap. See reference books for more complete discussion.
22. Carnivores generally have a shortened digestive tube, while herbivores usually have an elongated and folded one. The stomach of fish-eating prey is typically elongated (to accommodate the prey). Omnivores have sac-shaped stomachs (like humans) in most cases. See reference books for more complete information.

Discussion

This activity should be introduced after a study of fish anatomy because some of the procedures require a knowledge of anatomical features of the gills, mouth and internal organs. It is especially necessary if the optional dissection activity if attempted. This activity is probably one that should be attempted by more advanced students or at least those who are patient, adept and confident with laboratory activities. It should be emphasized repeatedly that the fishes should be handled carefully and the cotton wrap be moistened frequently with saltwater, as the fishes will undergo considerable stress if not handled properly. Some of the skills learned in this activity can be applied readily to feeding habit studies and anatomical studies of invertebrate organisms or even much larger marine vertebrates.

Evaluation

A variety of subjective and objective evaluations are possible to measure skills learned and mastery of the objective. One can evaluate the completeness of data gathered, the care and attention to detail used in making observations, technique with the microscopic examination, attention to scientific method used in devising the hypothesis, vocabulary understanding, thoroughness in studying the reference materials, completeness of drawings (but not artistic ability) and, in the optional activity, the dissection technique.

Follow-Up

- Scientifically minded students can extend this activity by setting up studies or experiments to work out other elements of the food webs or chains for these species. This involves more specific food habit studies (what they eat, not how), encompassing tropic levels both above and below the fish species studied.
- Comparative fish anatomy could be another natural outgrowth of the anatomical portions of this feeding habit classification activity.

References

Most good zoology, ecology, comparative anatomy and ichthyology texts would be valuable references. The following titles are just a few of the better known books of this type.

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